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Abstracts Bulletin

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Related to the Silicate Industries

CONTENTS

Original Papers:

Effect of Zirconia in Enamels for Sheet Steel—Wolfram 1
The Microscopic Identification of Stones in Glass—Insley 14
Studies on the Thermal Conductivities of Some Refractory Materials .. 19
The Firing of Refractory Products in France—Widemann 29
High Temperature Load and Fusion Tests of Fire Brick from the Pacific Northwest in Comparison with other Well-Known Fire Brick—Wilson 34
The Manufacture of an Insulating Brick from Diatomaceous Earth—Smith 52
The Dead Burning of Dolomite.—I—Robson and Withrow 61

Ceramic Abstracts 1

The Bulletin:

Editorials 1
Activities of the Society 4
Notes and News 44

Advertisers' Index 15

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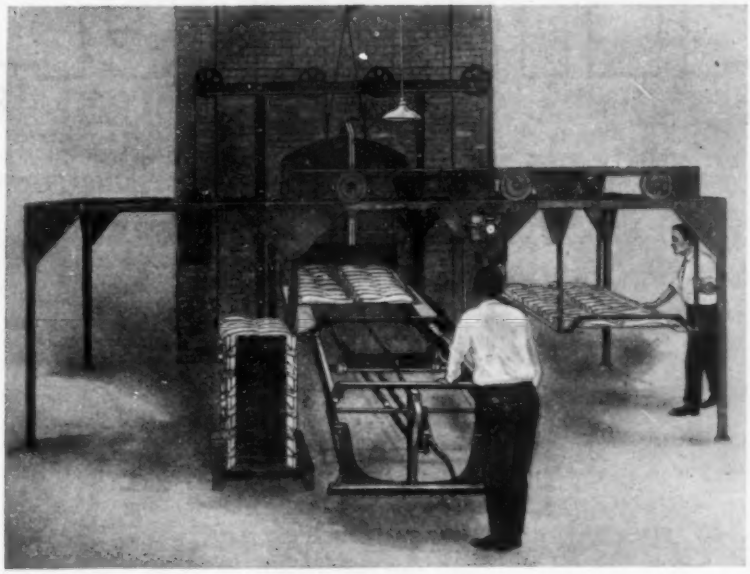

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ORIGINAL PAPERS

EFFECT OF ZIRCONIA IN ENAMELS FOR SHEET STEEL[1]

BY H. G. WOLFRAM

ABSTRACT

This paper deals with the results obtained from a study of the effect of additions of zirconium oxide to enamels for sheet iron and steel. The work includes additions of the zirconia to the raw smelter batch of both the ground and cover enamels, also the substitution of the zirconia for tin oxide in the mill batch. Several tests were used to determine its effect on some of the properties of the enamels, such as resistance to impact, thermal shock and acid.

1. Introduction

The every day use of enameled articles in the kitchen requires strong enamels, of good appearance and resistant to weak acids, impact and thermal shock. At the present time there is very little specific data at hand on the use of zirconia in enamels. Staley[2] in his paper entitled "Some Relations of Composition to Solubility of Enamels in Acids" states that zirconia and titanium oxide when substituted separately for small amounts of silica increase the resistance of various enamels to attack by acids. The zirconia is the most effective.

Fritz Kraze[3] in "Zirconium Fluoride in Glazes and Enamels" gives

[1] This paper is based upon the results obtained by the author in preparation of a thesis to meet the requirements for the degree of B.Sc. in Ceramic Engineering at the University of Illinois, June, 1923. Received November 3, 1923.

[2] H. F. Staley, *Jour. Amer. Ceram. Soc.*, **4** [9], 703 (1921).

[3] Fritz Kraze, *Ber. der Deut.*, **3**, 3 (June), (1922).

no specific data in his article but says that zirconia makes a stronger enamel which is more resistant to acids. He states that zirconium fluoride enamels display an astonishing elasticity, resisting rapid heating and cooling without injury. Zirconium gives considerable range when used with colors. Considerable zirconium makes a refractory frit and can be substituted in the mill for making opaque white enamels. In this substitution the action of the zirconium is mechanical and has a different opacifying effect than when acted upon by the fluorine in the fritting process.

Wenning[1] on "Zirconia in Sheet Iron Enamels" gives a short review of his work. A replacement up to 10% by zirconia of silica and alumina changes the working properties of the enamel very little. High replacements give viscous enamels. Enamels containing up to 10% zirconia are more elastic and test to be stronger enamels with better adhesion to the steel.

Wenning also says that zirconia when substituted in the mill formulas of low fluoride enamels gives a whiter enamel with opacity approaching very closely to that of tin oxide enamels. Such enamels are more acid resisting due to their low fluoride content. He summarizes by saying that enamels containing zirconia are more resistant to mechanical and thermal shock and acid. The zirconia is not affected by reducing furnace heat.

Staley[2] in "Materials and Methods for Cast Iron Wares" states that for a given opacity it is necessary to use slightly larger amounts of zirconia than tin oxide.

Grunwald[3] in his book gives a short review of the effect of zirconia on opacity of enamels; nothing definite is stated except that very pure zirconia increases the opacity slightly.

Morgan and Charles, Jr.[4] in their thesis "The Development of a Reflector Enamel" say that zirconia is not satisfactory as a substitute opacifier for tin oxide.

Danielson and Frehafer[5] in their paper "Opacifying Effect of Tin Oxide and Its Substitutes" state that zirconium oxide is nearly as good as tin oxide itself.

The above references point favorably toward the improvement of kitchen ware enamels by the use of zirconia. The following work was carried on in order to obtain definite results and data on its use.

2. Plan of Investigation

This investigation is concerned with the essential properties of kitchen ware enamels, namely, strength, resistance to acid and to thermal shock,

[1] W. F. Wenning, *Bull. Amer. Ceram. Soc.*, **6** [5], 102 (1923).

[2] H. F. Staley, Bur. Stand., *Tech. Paper* **142**, 57.

[3] Julius Grunwald and H. H. Hodgson, "Raw Materials for the Enamel Industry," 129 (1912).

[4] Morgan and Charles, Jr., Thesis, Univ. Ill., 34 (1920).

[5] R. R. Danielson and M. K. Frehafer, *Jour. Amer. Ceram. Soc.*, **5**, 634 (1923).

and opacity. For the purpose of getting useful results, typical commercial base enamels were used.[1] Additions of zirconia were made both in the smelter and mill batches for the cover coats and in the smelter batch for the ground coats. The base ground coat No. 1 was used, also additions of 2.5% zirconia to the base smelter formula for No. 2, and 5.0% zirconia to the base formula for No. 3.

Cover enamel Series A was made by additions of 2.5% and 5.0% zirconia to the smelter batch of the base formula. Another series (B) consisted of the base enamel A with 4.0% and 8.0% substitutions to the mill batch of zirconia for tin oxide.

The zirconia used was a commercial product analyzing 96% zirconia.

With this procedure there were three ground coats with five cover coats to be applied on each, giving fifteen different combinations.

3. Preparation of Enamels

1. A typical commercial ground coat was used in this investigation, namely:

	Batch weight
Borax	32.0
Feldspar	29.0
Quartz	19.0
Soda ash	9.0
Sodium nitrate	5.0
Fluorspar	4.7
Cobalt oxide	0.8
Manganese oxide	0.4
	99.9

The raw materials were fritted by heating to perfect fusion (determined by drawing a thread free from knots) in a crucible and pouring into cold water.

The frit was ground in approximately ten pound batches in a ball mill with constant mill addition of 8%, 1.75% borax (sol.) and 50% water. The additions of zirconia were made in the raw frit batch.

2. The base white enamel used was:

	Batch weight A-1
Borax	25.5
Feldspar	25.0
Quartz	21.0
Soda ash	3.5
Sodium nitrate	3.0
Cryolite	14.0
Antimony oxide	3.0
Zinc oxide	5.0
	100.0

[1] R. R Danielson, *Jour. Amer. Ceram. Soc.*, **3** [12], 961 (1923).

The raw materials were fritted by the drop frit method. Two series were made up; the first series A consisted of the base enamel and additions of zirconia in the raw frit batch; the second series B consisted of the base enamel A with the zirconia substituted in the mill batch to replace tin oxide. In series A 7% tin oxide was used in the mill. In all cases a constant mill addition of 6.0% clay, 0.25% magnesium carbonate and 60% water was used.

3. The kitchen ware upon which the enamel was applied consisted of six-inch commercial saucers. They were prepared by first scaling and then pickling in an 8% solution by weight of hydrochloric acid. The enamel was applied by the usual dipping method. The enamel after being "set up" showed no signs of settling and worked very well during the dipping process.

4. The enameling was accomplished in a small muffle furnace fired by city gas. The firing data are given in Tables I and II.

TABLE I

GROUND COATS

No.	Zirconia in smelt batch, %	Temp. of burning °C	Time, sec.
1	...	930	50
2	2.5	930	60
3	5.0	930	70

TABLE II

COVER COATS

Series	On ground No.	Temp. of burning 1st coat	Temp. of burning 2nd coat	Time, sec. 1st coat	Time, sec. 2nd coat
A_1	1	820	850	50	90
A_1	2	850	850	60	100
A_1	3	850	850	75	110
A_2	1	850	850	60	70
A_2	2	850	850	60	70
A_2	3	850	850	65	80
A_3	1	850	850	40	70
A_3	2	850	870	55	75
A_3	3	850	890	60	75
B_1	1	850	870	50	60
B_1	2	850	870	60	70
B_1	3	850	880	75	75
B_2	1	850	890	60	60
B_2	2	850	890	70	75
B_2	3	850	890	75	80

It is quite evident from the above data that the zirconia has a hardening effect upon the enamel. The increase in temperature and time for ma-

turity with increase of zirconia in most cases bears out this fact. An increase in viscosity with increasing zirconia was also noted in the smelting process both in the ground coats and cover enamels, but no data was obtainable, due to the varying conditions of that process.

The samples were very satisfactory in color and gloss. The surfaces were smooth and free from pinholes, fish scale and blisters.

4. Tests of Ware

Impact Test.—This test was carried on by use of the Bureau of Standards method and with apparatus suggested by the Bureau and shown in Figure 1. The piece was centered on the block and impact applied at the center, starting at one-tenth of a foot-pound and increasing in increments of twenty-five thousandths of a foot-pound. Failure was accepted when the enamel chipped over an area at least 0.25 inch in diameter.

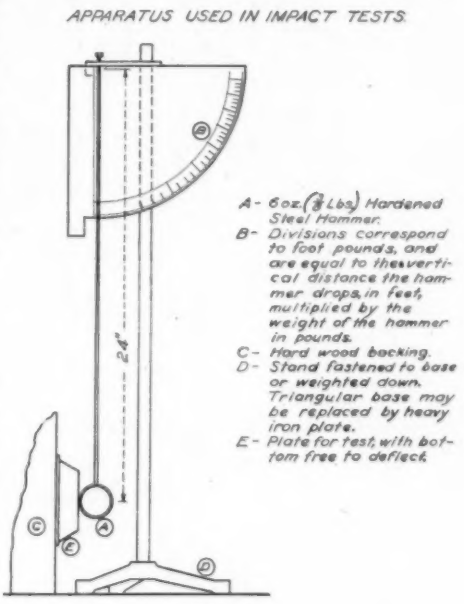
APPARATUS USED IN IMPACT TESTS
A- 6 oz. (⅜ Lbs.) Hardened Steel Hammer.
B- Divisions correspond to foot pounds, and are equal to the vertical distance the hammer drops, in feet, multiplied by the weight of the hammer in pounds.
C- Hard wood backing.
D- Stand fastened to base or weighted down. Triangular base may be replaced by heavy iron plate.
E- Plate for test, with bottom free to deflect.
24"

FIG. 1.

The results of the impact tests are shown in Table III.

By plotting curves for the averages of the tests, as in Figs. 2 and 3, it is very easy to compare the effects of the zirconia on both the ground and cover coats.

1. Ground Coats.—Increasing amounts of zirconia in the ground coats up to 2.5% increased the resistance to impact in all cases. Further increase in zirconia decreased the resistance where the A series of cover coats was used and showed no beneficial effects where the Series B (4 and 8% additions to the mill batch) was used.

2. Cover Enamels.—Increasing amounts of zirconia in the smelter batch of the cover enamels increased the resistance to impact in the cases where Nos. 1 and 2 ground coats were used. It gave a slight decrease and then a decided increase where No. 3 ground coat was used. Increased zirconia increased the resistance in the Series B where the zirconia was added at the mill. It is quite evident that the compositions of the ground coats and cover coats, also the combinations of the two, play an important part in the results obtained.

TABLE III

IMPACT TESTS—GROUND COAT NO. 1

Foot-pounds

Trial	0.100	0.125	0.150	0.175	0.200	0.225	0.250	0.275	0.300	0.325	Ft.-lbs., Average
A-1 White											
1				Slight crazing	Crazing	Fail					
2				Slight crazing	Fail						0.209
3				Slight crazing	Fail						
A-2											
1				No action	Slight crazing	Fail					
2						Crazing	Fail				0.259
3						Crazing	Crazing	Crazing	Fail		
A-3											
1						Crazing	Fail				
2	No action	No action	No action		No action	No action	Crazing	Crazing	Fail		0.283
3				No action		No action	No action	Slight crazing	Fail		
B-1											
1					Fail						
2						Crazing	Fail				0.225
3					No action	Fail					
B-2											
1						No action	Fail				
2							Fail				0.267
3							Crazing	Crazing	Fail		

TABLE III (*Continued*)

IMPACT TEST—GROUND COAT NO. 2

Trial	0.100	0.125	0.150	0.175	0.200	0.225	0.250	0.275	0.300	0.300	Ft.-lbs., Average
A-1 White											
1							No action	Fail			
2							Crazing	Fail			0.283
3							Crazing	Crazing	Fail		
A-2											
1							Crazing	Crazing	Fail		
2							Crazing	Crazing	Fail		0.300
3							Crazing	Crazing	Fail		
A-3											
1							No action	Crazing	Crazing	Fail	
2	No action	No action	No action	No action	No action	No action	No action	No action	Crazing	Fail	0.317
3							No action	No action	Fail		
B-1											
1							No action	Crazing	Fail		
2							No action	Fail			0.285
3							No action	Fail			
B-2											
1							No action	No action	Crazing	Fail	
2							No action	No action	Fail		0.300
3							No action	Fail			

TABLE III (*Continued*)

IMPACT TESTS—GROUND COAT NO. 3

Trial	0.100	0.125	0.150	0.175	0.200	0.225	0.250	0.275	0.300	0.325	Ft.-lbs. Average
A-1											
1						No action	No action	No action	Fail		
2						Crazing	Fail				0.275
3						No action	Crazing	Fail			
A-2											
1						No action	No action	Crazing	Fail		
2						Crazing	Fail				0.267
3						Crazing	Fail				
A-3											
1							No action	Fail			
2	No action	No action	No action	No action	No action		No action	Crazing	Fail		0.291
3							No action	Crazing	Fail		
B-1											
1							Crazing	Fail			
2						No action	Crazing	Crazing	Fail		0.284
3							Crazing	Fail			
B-2											
1							No action	Crazing	Fail		
2							No action	Crazing	Fail		0.300
3							No action	Crazing	Fail		

Resistance to Thermal Shock

The plan of investigation of the resistance to thermal shock was in accordance with a method used in some work at the Bureau of Standards, with slight variations suggested by C. W. Parmelee. The ware was placed in an oven of constant temperature of 100°C and quenched five times in cold water. This procedure was repeated at increasing temperature increments of 25°C until failure occurred. Failure was accepted when the enamel chipped off the body of the ware, differentiating from the bead.

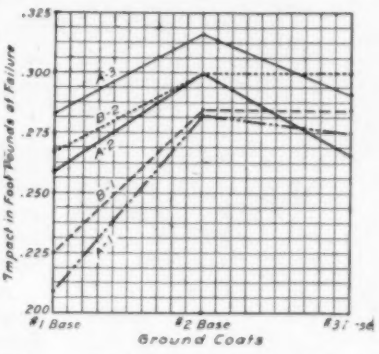

FIG 2.—Effect of zirconia on resistance of ground coats to impact.

After placing the ware in the heated oven, the temperature dropped decidedly. In order to insure perfect conditions, the ware was allowed to remain in the oven from fifteen to twenty minutes after the oven again reached the proper temperature before quenching.

Results are shown in Table IV, and graphically in Figs. 4 and 5.

The increase of zirconia in the ground coats gave a decided decrease in the resistance to thermal shock except in two cases. When A-1 cover coat was used on No. 2 ground coat, there was a decrease in resistance and when used on No. 3 ground coat, the resistance became normal again. There was no beneficial effect noted when B-1 cover coat was used.

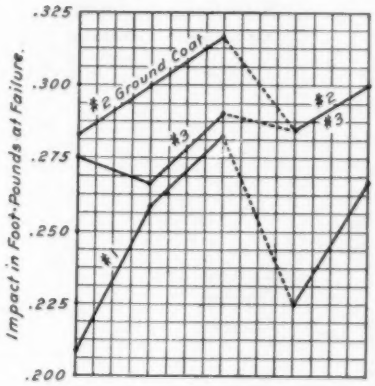

FIG. 3.—The effect of zirconia on resistance of cover enamels to impact.

When zirconia was increased in the cover coat smelter batches, part of them showed an increase in resistance, part of them no beneficial effect, while in the cases where the zirconia was added to the mill a decided increase in resistance was noted.

From the results obtained it was judged that for an increase of resistance to thermal shock it was best to add the zirconia to the mill batch of the cover coats only.

Resistance to Acid.—The resistance of the ware to solubility in acids was tested by using a cold 1% solution by weight of acetic acid. This solution was placed in the saucer and the ware was examined hourly for

failure. Failure was accepted when the ware showed a decided loss of gloss.

TABLE IV

GROUND COAT NO. 1

	Trial	100°C	125°C	150°C	175°C	200°C
A-1	1			No action	Crazing	
	2			No action	Failure	
	3			No action		
	4			No action		
	5			Crazing		
A-2	1			No action	Crazing	
	2			No action	Crazing	
	3			No action	Failure	
	4			No action		
	5			Crazing		
A-3	1				Crazing	
	2	No action	No action		Crazing	
	3				Failure	
	4					
	5			No action		
B-1	1				Crazing	
	2				Crazing	
	3				Failure	
	4					
	5				No action	No action
B-2	1				No action	No action
	2				No action	No action
	3				No action	Crazing
	4				No action	Crazing
	5				No action	Failure
	6					

GROUND COAT NO. 2

A-1	1			No action		
	2			No action		
	3			Crazing		
	4			Crazing		
	5			Failure		
A-2	1				Crazing	
	2				Crazing	
	3				Failure	
	4			No action		
	5					
A-3	1				Crazing	
	2	No action	No action		Failure	
	3					
	4			Crazing		
	5			Crazing		
B-1	1				Crazing	
	2				Crazing	

TABLE IV (*Continued*)

	3				Failure	
	4					
	5					
B-2	1			No action	No action	Crazing
	2				No action	Crazing
	3				No action	Crazing
	4				No action	Failure
	5				No action	

GROUND COAT NO. 3

A-1	1			No action	Crazing	
	2			No action	Failure	
	3			No action		
	4			No action		
	5			Crazing		
A-2	1			No action	Failure	
	2			No action		
	3			No action		
	4			Crazing		
	5			Crazing		
A-3	1			No action		
	2	No action	No action	No action		
	3			Crazing		
	4			Failure		
	5					
B-1	1				No action	
	2				Crazing	
	3				Failure	
	4					
	5					
B-2	1			No action	No action	Failure
	2				Crazing	
	3				Crazing	
	4				Crazing	
	5				Crazing	

TABLE V

RESISTANCE TO 1% ACETIC ACID SOLUTION

Cover coat	Hours of loss of gloss
A-1	First
A-2	First
A-3	First
B-1	Second
B-2	Second

There was no beneficial action obtained by increasing the zirconia in the smelter batch of the cover coats. All of this ware failed the first hour. Some benefit was obtained by substituting the zirconia in the mill batch for the tin oxide.

The Effect of Zirconia on Opacity.—A comparative visual examination only was used to determine the effect on opacity of increasing the zirconia. In the A series, where tin oxide was a constant addition to the mill, no benefit was obtained although no difference could be detected between the A-1 base enamel and the others.

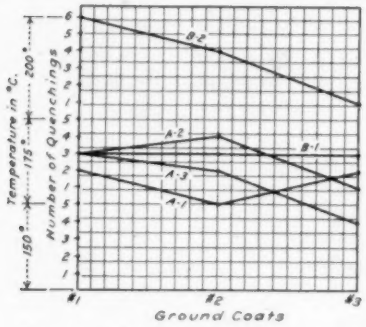

FIG. 4.—The effect of zirconia on resistance of ground coats to thermal shock.

Series B where zirconia was added at the mill to replace the tin oxide, gave an interesting comparison. It was found that B-1, 4% addition of zirconia to replace 7% of tin oxide, gave an enamel equally as white as the tin enamel but lacking in covering power. The B-2 cover coat, with 8% addition of zirconia replacing 7% tin oxide, gave an enamel equally as white as tin with an equal or better opacity.

5. Conclusions

It is plain that the effects produced by the zirconia are dependent upon the composition of the enamel and upon the combination of cover and ground coats.

1. Zirconia additions to the smelter batch increased the time of smelting. All additions of zirconia make the enamel more viscous and thus increase the time of burning.

2. Increasing additions of zirconia to the ground coat smelter batch increases the resistance to impact.

Increasing additions to the cover coat smelter batch gave the best results and highest resistance although increasing amounts, when substituted for tin oxide in the mill, gave increasing resistance.

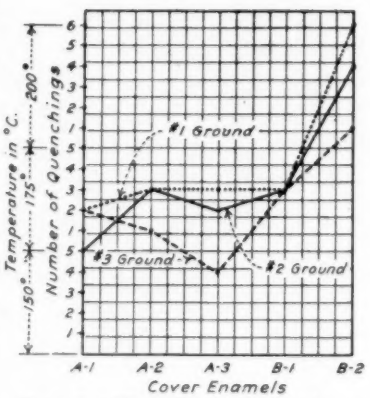

FIG. 5.—The effect of zirconia on resistance of cover coats to thermal shock.

3. Although the resistance to thermal shock of the zirconia enamels is higher than the tin enamels, increasing amounts of zirconia in the smelter batch decreases the resistance. Increased substitutions of zirconia for tin oxide in the mill increases the resistance to thermal shock.

4. Additions of zirconia to the smelter batch did not increase the

resistance to attack by acid. Substitution of zirconia for tin oxide in the mill did show a beneficial action by slightly increasing the resistance.

5. Zirconium oxide can be used as a satisfactory substitute opacifier for tin oxide in the mill additions.

6. Summary

The use of zirconia in kitchen ware enamels is beneficial in its effect upon the essential properties of the enamel. It was found that the resistance to acid was increased in agreement with the statement of Staley.[1] The enamels were made stronger and more resistant to thermal shock here confirming the investigation of Fritz Kraze.[2] It was also found in accordance with Wenning's[3] conclusions that zirconia makes a more viscous enamel, gives a good white body with opacity as good as tin oxide.

The results on opacity do not agree with those of Morgan and Charles, Jr., that zirconia could not be used as a substitute opacifier for tin. This disagreement may be due to two causes; first, they give no statement as to the source of the zirconia used, and may have had an inferior grade; second, the composition of the white used is not in agreement with the base white of this investigation. The white base used by Morgan and Charles, Jr., was a high fluoride enamel while the base white used in the work was an antimony enamel high in cryolite, also containing zinc oxide.

A further field of investigation could be suggested in which the compositions of the enamel and combinations of ground and cover coats could be worked out to give very satisfactory results.

The writer wishes to extend his hearty appreciation and thanks to the Coonley Manufacturing Company for the samples of ware, also to Dr. Miner of the Welsbach Company for the zirconia used in the above investigation, and to R. R. Danielson and C. W. Parmelee for the many helpful suggestions toward the completion of this work.

CERAMIC DEPARTMENT
UNIVERSITY OF ILLINOIS
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[1] Staley, *loc. cit*
[2] Kraze, *loc. cit.*
[3] Wenning, *loc. cit.*

THE MICROSCOPIC IDENTIFICATION OF STONES IN GLASS[1]

By Herbert Insley

ABSTRACT

For the identification of stones in glass, it is not only necessary to observe the external form of the crystalline substances forming the stones, but also to determine their optical properties by means of the polarizing microscope.

A brief description of the method of preparation of stones for microscopic examination is given.

The principal optical properties and distinguishing characteristics of the crystalline substances occurring in stones in the soda-lime glasses are noted.

Introduction

Bowen[2] has pointed out that, because of their crystalline nature, stones in glass may be readily identified by means of the polarizing microscope. He has also shown that the source of the stone is indicated by the composition and structure of the crystals, and he has given the optical properties of the stones found in optical glass. In a recent paper, the writer[3] has shown that the stones occurring in tank glasses, although in part of different compositions from those found in pot glasses, can also be identified and traced to their sources by the use of the polarizing microscope.

The impression seems to have been left with glass technologists that stones could be identified by their external form alone. Many crystalline compounds have widely differing compositions, although very similar in external form, and it is, therefore, necessary to determine the optical properties before satisfactory identification can be made. The object of the present paper is to note the methods of examination and to give the distinguishing properties of the crystalline compounds occurring in the soda-lime glasses.

A knowledge of the composition of stones in glass should enable the plant technologist to eliminate them since he already has information on the batch composition, the temperature conditions in the tank and the condition of the tank walls. The polarizing microscope affords him a means of determining the composition of the crystalline parts of the stones which is more exact and more rapid than that of chemical analysis. A working knowledge of the methods of determining the optical properties of crystalline materials is, of course, essential to the efficient use of the polarizing microscope.[4]

[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] N. L. Bowen, "The Identification of Stones in Glass," *Jour. Amer. Ceram. Soc.*, **1**, 594–605 (1918).

[3] *Jour. Amer. Ceram. Soc.*, **6** [6], 706–16 (1923).

[4] The following books are of great assistance in understanding the theory of optical crystallography as well as the methods of optical measurement with the microscope: Albert Johannsen, "Manual of Petrographic Methods." Second edition. McGraw-Hill Book Co., 1918. (A complete discussion of theory as well as a compilation of

One of the most important properties to be determined is the index of refraction. To make this determination, it is necessary to crush the specimen to a powder and immerse in liquids of known index of refraction. Before crushing, the stone should be freed from the surrounding glass as much as possible. This can be done by breaking the glass containing the stone into fragments one-sixteenth to one-thirty-second of an inch in diameter and separating the stony material from the clear glass by means of a probe under the binocular microscope. All of the optical properties may be determined by the use of the immersion method, but for the preservation of typical stones and for the observation of structure, thin sections are very valuable.

The source of the stone is sometimes indicated by its manner of occurrence. Stones derived from the tank walls are frequently accompanied by lumps in the finished glass. Grains of undissolved sand may be altered wholly or in part to the high temperature modifications of silica and may frequently be surrounded by devitrification crystals of tridymite. Other undissolved batch constituents also may be surrounded by aureoles of devitrified glass, the crystals in the devitrified area having a chemical composition closely related to that of the undissolved batch constituent. Devitrification crystals frequently occur as radiating spherulites or feathery aggregates.

A list of the crystalline compounds occurring in the soda-lime glasses is given below. The optical properties of each compound, the usual habit of the crystals, their associations, the different types of stones in which they occur, and the properties most useful for distinguishing them from other crystalline materials in glass are also noted.

Quartz.—(SiO_2)—Stable below 870°C. Usually occurs as grains with rounded and sometimes embayed faces. Crystals with well developed faces are seldom, if ever, seen in stones. Its indices of refraction are: $\omega = 1.544$, $\epsilon = 1.553$, and it is uniaxial positive in optical character. It has no recognizable cleavage. Its characteristic properties are its indices of refraction, its double refraction, the shape of the grains and its associations. Quartz has never been observed as a crystallization product of the glass and is only found in either batch or tank stones (stones derived from the refractory walls of the tank). In batch stones it is sometimes the only crystalline material, but more usually it is associated with tridymite

methods); Esper S. Larsen, "The Microscopic Determination of the Nonopaque Minerals," U. S. Geol. Surv., *Bull.* **679** (1921). (Gives a discussion of the immersion method as an introduction to a list of the optical properties of the known minerals); N. H. and A. N. Winchell, "Elements of Optical Mineralogy." 2d ed., Pt 1. D. Van Nostrand and Co., 1922. (A concise discussion of theory as well as of modern practice); F. E. Wright, "The Methods of Petrographic-Microscopic Research." Carnegie Inst. Washington, *Pub.* **158** (1911). (A discussion of the accuracy and limitations of the methods of optical mineralogy).

and cristobalite. In tank stones it is associated with dehydrated clay substance, sillimanite, etc.

Tridymite.—(SiO_2)—Stable between 870° and 1470°C. Tridymite may occur in hexagonal plates or wedge-shaped and interpenetration twins, depending on the mode of formation. Devitrification crystals are usually simple hexagonal plates, crystals resulting from the inversion of quartz grains are usually twinned. The indices of refraction are $\alpha = 1.469$, $\beta = 1.470$, $\gamma = 1.473$. The optical character is biaxial positive and the acute bisectrix is normal to the hexagonal plate. The crystals are probably orthorhombic. The hexagonal plates are most frequently seen turned on edge when they appear as needles or laths with parallel extinction and negative elongation (elongation = α). Plates arranged in parallel layers are abundant.

Tridymite occurs in batch stones where the undissolved constituent is quartz, in devitrification stones, in crown drops and frequently in the scum on the melting surface of tanks. In batch stones it occurs either as hexagonal plates or wedge-shaped twins and is usually associated with quartz and sometimes with cristobalite. The large white spheres so frequently found in devitrified glass sometimes contain hexagonal plates of tridymite arranged irregularly with respect to each other and in a matrix of glass. Under the microscope the plates appear as needles or laths. Tridymite appears as large wedge-shaped or more intricate twins in crown drops and simple hexagonal plates are rarely seen. In scums on the melting surface where the crystallizing constituent is silica, tridymite usually forms the uppermost part of the scum, cristobalite forms the lower layer of the scum and there is a gradual transition between the layer predominantly cristobalite and the layer predominantly tridymite. Tridymite in scums may appear as hexagonal plates, wedge-shaped twins or both. The distinguishing properties of tridymite are the indices of refraction, the character of the elongation of the upturned hexagonal plates, the wedge-shaped twins and the crystalline materials with which it is associated.

Cristobalite.—(SiO_2)—Although cristobalite's stability range is from 1470°C to its melting point, it appears at temperatures which are considerably less than 1470°. It very often is the intermediate crystalline form of silica in the inversion of quartz to tridymite and it sometimes crystallizes directly from the melt at temperatures below 1470°. Cristobalite most frequently appears as very small skeleton crystals[1] arranged in parallel growths. Complete crystals have never been observed in glass by the writer. The indices of refraction of cristobalite are about 1.484 and 1.487 and the double refraction is very low. Cristobalite occurs in batch stones associated with tridymite and undissolved quartz grains, in scums on the melting surface associated with tridymite, and in devitri-

[1] Fenner, *Amer. Jour. Science*, **36** [4], 355 (1916).

fication crystals. In devitrification crystals the pine-tree growths are characteristic.[1] Cristobalite is readily identified by its index of refraction and characteristic skeleton crystals and parallel growths.

Wollastonite.—($CaO.SiO_2$)—Wollastonite is monoclinic with its elongation parallel to the crystallographic *b* axis and consequently it appears to have parallel extinction. It occurs in laths or needles. Since the vibration direction β is parallel to the elongation, the elongation may be positive or negative, but due to the fact that the index of refraction β is very much closer to γ than it is to α, the elongation usually appears positive. The indices of refraction are $\alpha = 1.616$, $\beta = 1.629$, $\gamma = 1.631$. The optical character is biaxial negative. Wollastonite occurs only as a devitrification product and usually as radiating feathery or spherulitic aggregates. Wollastonite may be distinguished from sillimanite by its slightly lower indices of refraction, its habit and the fact that the laths are somewhat broader than the sillimanite needles. It may be distinguished from diopside by its lower indices of refraction and its parallel extinction.

Diopside.—($CaO.MgO.2SiO_2$)—Diopside has been observed in two instances by the writer, once as a devitrification spherulite and once as the crystalline constituent of the scum on the melting surface of a tank. In both cases the limestone used in the batch was dolomitic. Diopside can evidently only occur as a devitrification product where magnesian limestone or some magnesia compound is used in the batch.

Diopside occurs in slender prismatic crystals with a maximum extinction angle of about 40°C. The indices of refraction are $\alpha = 1.673$, $\beta = 1.680$, and $\gamma = 1.702$.[2] It is biaxial positive in optical character. Diopside is easily distinguished from other crystalline compounds in glass by its indices of refraction and its extinction angle.

Sodium-Calcium Silicate.—The exact formula of this compound is not known. It occurs in slender crystals as a devitrification product. The prismatic crystals have a hexagonal or octagonal cross-section. The indices of refraction are: $\alpha = 1.562$, $\gamma = 1.577$[3] and the optical character is biaxial positive. The extinction is parallel and the elongation is positive ($= \gamma$). The indices of refraction, habit, and character of elongation are sufficient to distinguish this material from other crystals occurring in glass.

Sillimanite.—($Al_2O_3.SiO_2$)—Sillimanite is found only in stones derived from the pot or tank walls. It occurs in orthorhombic needles and slender laths which have a characteristic appearance. Its indices of refraction are: $\alpha = 1.638$, $\beta = 1.642$, $\gamma = 1.653$. Sillimanite has parallel extinction and

[1] *Jour. Amer. Ceram. Soc.*, **6**, 708 (1923).

[2] The indices given were determined on crystals occurring in a scum on the melting surface of a tank. They are somewhat higher than those given for pure artificial diopside by Wright and Larsen, *Am. Jour. Sci.*, **27**, 1 (1909).

[3] Indices were determined by the writer.

positive elongation (= γ). It is very frequently associated with dehydrated clay that has not dissolved in the glass or transformed to sillimanite and is sometimes associated with quartz grains or corundum crystals. Sillimanite can be identified by its indices of refraction, crystal habit, extinction and character of elongation.

Corundum.—(Al_2O_3)—Stones containing corundum have, without doubt, been derived from the refractory walls of the pot or tank. Corundum crystals, as they occur in glass, are very thin, hexagonal plates. The indices of refraction are: $\omega = 1.768$, $\epsilon = 1.760$ and the optical character is uniaxial negative. The double refraction is so low and the plates are usually so thin that interference figures are very faint. The hexagonal plates turned on edge appear as very fine needles with positive elongation. Corundum crystals, which are small (0.002–0.08 mm.) have rounded edges and are associated with clouds of fine-grained amorphous particles, have probably been derived from refractory material below the glass line which contained a high percentage of alumina. Larger corundum plates (0.1–2.0 mm.) which have well defined edges and are not associated with fine-grained amorphous particles have been produced by the action of the soda in the furnace atmosphere upon flux blocks above the glass line. The index of refraction and the crystal form of corundum are usually sufficient to distinguish it from other materials occurring in stones.

Nephelite.—($Na_2O.Al_2O_3.2SiO_2$)—Nephelite has been frequently found by the writer in flux blocks above the glass line which has been exposed to the soda in the furnace atmosphere, but it has been found in a stone in glass in only one case. Here it was associated with corundum and was evidently formed by the action of the molten glass on the corundum under unusual conditions. In thin section the nephelite crystals had a hexagonal cross-section and showed a faint but unmistakable uniaxial negative interference figure. The double refraction was very low, and the index of refraction was slightly less than that of Canada balsam (about 1.54).

Amorphous Substances.—Pot or tank stones very often contain what appear to be opaque masses under low power, but are in reality clouds of very fine, apparently amorphous particles which have resulted from the dehydration and dissociation of the clay minerals. Identification of such masses would be very difficult except that they are almost always associated with masses of sillimanite needles and with rounded and partially dissolved quartz grains.

When salt cake or calcined alumina is used in the glass batch, large stones containing balls of these undissolved materials are sometimes formed. Since the particles making up such stones are very fine and amorphous, identification by means of the microscope is impossible and it is necessary to resort to chemical analysis. Fortunately, stones of this type are usually large and are easily separated from the surrounding glass.

STUDIES ON THE THERMAL CONDUCTIVITIES OF SOME REFRACTORY MATERIALS[1]

ABSTRACT

The method used was a modification of that described by Hepplewhite. The changes made were for the purpose of insuring greater accuracy. An effective means for preventing lateral flow of heat was devised. The coefficients obtained for the several materials studied were (c. g. s. units) silica brick .00099, fire clay brick .00169, fire clay slab .00203, light weight fire clay brick .00251, sillimanite brick .00432, electrically sintered magnesia brick .00655, "Alundum" fire brick .00833, "Crystolon" silicon carbide brick .00982.

[The work for this paper including the design, erection and operation of the apparatus, most of the calculations and the preparation of the detailed report was done by O. S. Buckner.]

Object

These studies were made for the purpose of obtaining reliable conductivity coefficients on several types of refractory bricks made from ceramic bonded electric furnace products. Intelligent use of a new refractory material cannot be made without accurate data. Engineers engaged in furnace design must necessarily know the coefficients of the refractories they are working with in order to determine properly wall thicknesses and to provide for suitable insulation.

Method of Test

The method used in these tests was a modification suggested by Hepplewhite.[2] Hepplewhite devised his method to determine the conductivity of silica refractories at high temperatures. A relatively short temperature gradient through the test piece was used, 1350 to 850°C. The thickness of the test piece was 3 inches.

In order to adapt this method to refractories having a high relative conductivity like fused alumina and silicon carbide the size of the test piece was reduced in area to a circular piece $8\frac{1}{2}$ inches in diameter. Care was taken to prevent diffusion of furnace gases into the test piece by protection of the lower surface with a dense refractory plate. An additional air calorimeter or guard ring was placed around the calorimeter on which measurements were taken in order to maintain the entire upper surface at an even temperature. These precautions were not taken by Hepplewhite and it would seem that the result he has obtained on bonded silica is too high. That is, furnace gases are likely to seep through the test piece carrying heat with them to the upper surface of the test piece. Further, failure to maintain the upper surface at an even temperature would

[1] A contribution from the Research Laboratories of the Norton Co., Worcester, Mass. Received November 9, 1923.

[2] *Bull. Amer. Ceram. Soc.*, **1** [Feb. 20], 5 (1922).

result in lateral flow and this lateral flow, in the case of Hepplewhite's method, would be toward and into the calorimeter.

Below is given a sketch of the apparatus used in these tests (Fig. 1) and a photograph of the set-up (Fig. 2).

Description of Apparatus

Furnace.—The furnace used was a 2-burner gas-fired pot furnace approximately 16 inches in diameter on the inside and 10 inches deep. A 9 x 5 inch round "Crystolon" refractory block was placed in the center of the chamber as a heat retainer. The top was covered with two 29-inch diameter semi-circular fire clay slabs, 3 inches thick, through which at the center was cut an 8-inch round hole. Midway between the burners and at the outside edge of these slabs two diametrically opposite vents were cut for the exit of burned gases. Over the 8-inch hole the test specimen was placed. This was $8\frac{1}{2}$ inches in diameter and in most cases 2 inches thick. The lower side was protected from direct contact with the gas flames by a "Crystolon" refractory plate $\frac{3}{8}$ inch thick. Between this plate and the test specimen was also $\frac{1}{4}$-inch RA 162 "Alundum" cement. This plate and cement also held the platinum platinum-rhodium thermocouples in place. These latter were in the plane of the lower surface and extended $2\frac{1}{2}$ inches from the outside circumference toward the center of the specimen. They were placed diametrically opposite. The only protection provided for the wires of the couples was "Alundum" insulation tubing and about $\frac{1}{4}$-inch pure 38 "Alundum" abrasive packed around the end of the couple itself. The lower surface had to be grooved about $\frac{1}{8}$ inch deep to permit the couple wires being placed in the plane of the lower surface. Three base metal couples were used to measure the temperature of the upper surface. These were placed parallel to one another in grooves about $\frac{1}{8}$ inch deep, $2\frac{1}{2}$ inches apart. The couple joints themselves were all on one diameter of the upper surface. No insulation was necessary

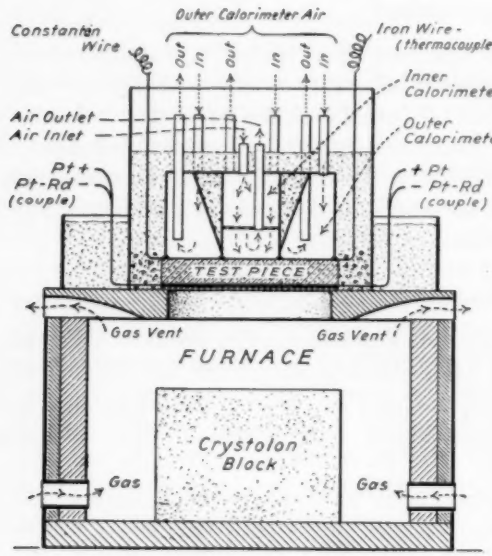

FIG. 1.—Construction and arrangement of the calorimeters.

since the positive and negative wires were in one straight line. The grooves in which the wires were placed were filled up with a mixture similar in composition to the block being tested, the wires and couple joint being covered to a depth of $^1/_{16}$ inch.

The calorimeter was made of thin sheet iron and was 4 inches in diameter and 6 inches high. Air was blown into the top of this calorimeter at the center, broken up and distributed over the top of the specimen below by means of a perforated plate 2 inches above the specimen. The air came into direct contact with the specimen and passed out through the top by means of a $^1/_2$-inch pipe opening below the perforated plate. The temperatures just above the calorimeter of the ingoing and outgoing air were measured with mercury thermometers. An outer calorimeter or guard ring was employed to keep the remainder of the top surface of the specimen at the same temperature as that portion covered by the inner calorimeter. This outer calorimeter touched, but was not joined to, the inner calorimeter, $^1/_4$ inch above the surface of the test piece. Except at this point they were separated with powdered kieselguhr tightly packed in between them. The bottoms of the calorimeters were sealed to the top of the test specimen with RA 162 "Alundum" cement, a thin layer being applied to each in the same manner as putty is used on window glass. This cement was also coated over with a thick solution of silicate of soda. There were five openings and five exits for air evenly spaced about the top of the outer calorimeter. The lower ends of these pipes were flush with the top of the calorimeter in the case of the former and one inch above the surface of the specimen in case of the latter.

FIG. 2.—Set-up of the apparatus.

A 15-inch diameter galvanized iron hoop was placed around the test piece and calorimeter, and the test piece and calorimeter were protected from loss of heat by tightly packed kieselguhr with which the hoop was filled to a point about $1^1/_2$ inches above the calorimeters. To a point

slightly above the test piece, quartz was added to the kieselguhr to reduce the shrinkage in this material.

Air was furnished the calorimeter by means of a small electric blower and the volume delivered to the inner calorimeter was measured by means of an 8-lamp gas meter. The pressure and temperature of the air was also measured at the meter. A small steel tank was interposed between the blower and the motor to thoroughly mix the air, for it became slightly heated in passing through the blower. Connection was made from the tank to both outside and inside calorimeters by $^1/_2$-inch steel pipe and rubber tubing.

The noble metal couples on the bottom surface of the test specimen were calibrated after every two runs. They varied very little throughout the study except in the test of the "Crystolon" refractory. In this case it was found necessary to protect the thermocouple wires with "Alundum" tubing which had been rendered impervious by a glaze of porcelainic composition. The hot junction of the couple was similarly protected by packing it in "Alundum" cement and then painting a raw porcelainic glaze over the cement. Silicon fumes probably were the cause of the trouble. Due to oxidation the base metal couples had to be replaced three or four times.

The accuracy of the gas meter used was not known. However, it had just been calibrated before being borrowed from the Worcester Gas Light Company. In a talk which Mr. Buckner had with Mr. Bauer of the Providence Gas Company he was told that gas meters were very accurate measuring devices; that of 20,000 meters used in Providence in 1920, the maximum error found in this number after one year's use was 2%.

Composition of Test Pieces

The pressed fire clay mixture consisted of $12^1/_2$% sandy and $37^1/_2$% of plastic fire clay with 50% by volume of 3- to 16-mesh fire clay grog. The grog was reclaimed from broken slabs and saggers. The light weight refractory had a bulk specific gravity of 1.7. The weight of the standard 9-inch brick was 5.1 lbs. Its composition was plastic fire clay 40%, lignitic clay 40%, 3- to 16-mesh grog 10%, and 16 F grog 10%. These were fired to cone 13.

The sillimanite, electrically sintered magnesia, fused crystalline alumina and silicon carbide refractories were made by crushing the electric furnace products to pass a No. 14 screen and bonding with fire clay. The sillimanite contained 15% of bond, the fused alumina and silicon carbide 10%, and the magnesia 3%. These were fired to cone 16.

Two brands of commercial refractories were also tested, a silica brick composition and a Pennsylvania fire clay composition.

The average chemical compositions of the materials are as follows:

	"Alundum" fused alumina	"Crystolon" silicon carbide	Sillimanite	Electrically sintered magnesia	Bond clay
SiO_2	1.0 –2.5%	..	35.75%	..	59.55%
Fe_2O_3	0.25–1.0	..	1.92	..	2.31
TiO_2	1.5 –4.0	..	2.60	..	1.33
Na_2O	trace	..	..	..	..
Al_2O_3	92.0–96.0	..	59.73 by diff.	..	25.41
ZrO_2	trace–1.25	..	..	..	..
CaO	0–trace	..	..	..	0.46
MgO	0-trace	..	..	92.0–95.0%	0.33
SiC	..	98.0%	..	..	..
$K_2O + Na_2O$	..	..	..	..	1.01
Loss	..	..	..	..	9.10

	Pressed fire clay mixt.	Light wt. fire clay mixt.
SiO_2	67.11%	66.77%
Fe_2O_3	1.61	1.52
TiO_2	1.30	2.00
Al_2O_3	28.20	28.94
CaO	0.80	trace
MgO	1.60	trace
$K_2O + Na_2O$	0.48	0.95
Loss	0.27	0.18

Porosity of Mixtures

The porosities of the test specimens were calculated from the dry, saturated and suspended weights.

	Porosity		Porosity	
Star silica No. 2	27.7%			one
Star silica No. 3	..	Sillimanite	15.2	sample
H. W. fire clay No. 1	..			only
H. W. fire clay No. 2	..			one
Pressed fire clay No. 2	24.9	Magnesia	23.4	sample
Pressed fire clay No. 3	24.9			only
Light weight fire clay No. 1	42.5	"Alundum" fused alumina No. 1	14.3	
Light weight fire clay No. 3	41.2	"Alundum" fused alumina No. 2	13.6	
		"Crystolon" silicon carbide	29.14	

Operation of Apparatus

The temperature of the furnace was slowly raised over a period of 6 to 7 hours in all tests till the temperature of the bottom of the specimen reached 1250°C. When the bottom had reached about 900°C it was found necessary to turn on the blower and admit air to the calorimeters in order to prevent the rubber connections from charring. A strong current was first admitted to the inner calorimeter, and if the seal at the bottom was not tight, air could be felt issuing from the exit pipes on the outer calorimeter. Readings of the three base metal couples on the top surface were made shortly after turning the air into the calorimeters and the

supply regulated to give equal temperatures at the three points. The top surface gradually rose to 650°C and the supply of air was so regulated as to hold it constant at this point. When the apparatus became thermally balanced the air pressure and the psychrometer were read. The duration of the tests was 20 minutes, and each minute temperature readings were taken of ingoing and outgoing air at the calorimeter. The pressure and temperature of the air at the meter were also read. Knowing the volume of air which passed through the meter in 20 minutes, there were sufficient data to calculate the coefficient of conductivity.

Method of Calculation of Coefficient

The following is a sample calculation. These data were obtained on run No. 2, "Star" silica.

Barometric pressure, 743.45 (corrected)
Average temp. of air at meter, 34.1°C
Manometer at meter, 0 mm.
Volume of air used, 8 8 cu. ft.
Vapor pressure, 14.27 mm. (obtained from psychrometer readings. See Psychrometric Tables W. B No 235, U S. Dept. of Agr.).
Average temperature of ingoing air at calorimeter, 42.58°C
Average temperature of outgoing air at calorimeter, 232.29°C
Thickness of block, 4.121 cm.
Area of calorimeter, 80.58 sq. cm.
Temperature of lower surface of test piece, 1250°C
Temperature of upper surface of test piece, 650°C
Duration of test, 1200 sec.
Specific heat of H_2O vapor, .468 (Smithsonian tables)
Specific heat of air, .237
Weight in gms. of 1 cu. ft. dry air, 36.61
Weight in gms. of 1 cu. ft. H_2O vapor, 22.775

Since the volume of a gas is directly proportional to the absolute temperature and inversely proportional to the pressure, the volume of air used calculated to standard conditions becomes:

$$\frac{8.8}{V} = \frac{307.1 \times 760}{273 \times 743.45}$$

$$V = 7.65 \text{ cu. ft.}$$

As used, this air contained sufficient moisture to give a vapor pressure of 14.27 mm. The volume of water vapor present bears the same relation to the volume of air as the vapor pressure does to the total pressure.

$$7.65 \text{ cu. ft.} \times \frac{14.27}{743.45} = .146 \text{ cu. ft. } H_2O \text{ vapor}$$

$$7.65 - .146 = 7.504 \text{ cu. ft. dry air.}$$

The amount of heat carried out of the calorimeter by these two gases is equal to their respective weights multiplied by the rise in temperature and their specific heats, or

$7.504 \times 36.61 = 274.72$ gms. of dry air
$274.72 \times (232.29° - 42.58°) \times .237 = 12{,}351.76$ calories
$.146$ (H_2O vapor) $\times 22.775 = 3.325$ gms. H_2O
$3.325 \times (232.29° - 42.58°) \times .468 = 295.20$ calories
$12{,}351.76 + 295.20 = 12{,}646.96$, total calories taken from calorimeter.
The coefficient of conductivity =

$$\frac{\text{Heat} \times \text{thickness}}{\text{Area of calorimeter} \times \text{temp. difference of sides} \times \text{time in sec.}}$$

Therefore,

$$K = \frac{12{,}646.96 \times 4.070}{80.58 \times 600 \times 1200} = .00089.$$

The area of the calorimeter used here was obtained by moistening the lower edge of the calorimeter with ink, making several imprints on paper and taking the area of these circles with a planimeter. The outside area was used in the calculation since the metal of the calorimeter absorbed heat from the block and gave it up again to the calorimeter air.

The "thickness of block" used in the calculations above is the thickness of the test specimen minus $^1/_{16}$ inch or the actual distance between the thermocouples on the bottom and upper sides of the test piece.

Data

TABLE I[1]

	Silica No. 2	Silica No. 3	H. W. fire clay No. 1	H. W. fire clay No 2.
Barometric pressure	743.45 mm. Hg	744.0	746.7	744.8
Volume air used	8.8 cu. ft.	6.67	11.07	13.32
Vapor pressure	14.27 mm.	5.56	7.0	12.85
Air at meter	34.1°C	27.3	30.85	42.77
Manometer	0.0	..	..	..
Calorimeter air (in)	42.58°C	39.7	40.76	50.65
Calorimeter air (out)	232.29°C	288.19	304.0	297.54
Thickness of test piece	1.665"	2.02	1.728	1.71
Temperature of bottom	1250°C	1250	1250	1250
Temperature of top	650°C	650	650	650

	Pressed fire clay No. 2	Pressed fire clay No. 3	Light weight fire clay No. 1	Light weight fire clay No. 3
Barometric pressure	740.0 mm. Hg	745.8	744.0	745.8
Volume air used	16.70 cu. ft.	12.60	15.79	15.96
Vapor pressure	21.3 mm.	16.20	12.5	14.9
Air at meter	40.3°C	39.5	36.0	36.6
Manometer	..	..	..	..
Calorimeter air (in)	45.0°C	50.11	43.2	47.94
Calorimeter air (out)	251.0°C	280.68	314.5	280.03
Thickness of test piece	2.04"	2.04	1.97	1.97
Temperature of bottom	1250°C	1250	1250	1250
Temperature of top	650°C	650	650	650

[1] The values given for temperature are averages.

	Sillimanite No. 3	Sillimanite No. 4	Magnesia No. 1	Magnesia No. 2
Barometric pressure	748.21 mm. Hg	747.7	744.0	741.3
Volume air used	34.95 cu. ft.	34.37	50.22	47.9
Vapor pressure	17.45 mm.	17.06	15.87	0.24
Air at meter	42.88°C	46.05	28.7	29.0
Manometer	1.0 mm.	1.0	2.0	2.0
Calorimeter air (in)	53.86°C	56.2	35.3	34.4
Calorimeter air (out)	252.0°C	245.76	239.0	242.4
Thickness of test piece	2.053″	2.053	1.983	1.983
Temperature of bottom	1250°C	1250	1250	1250
Temperature of top	650°C	650	650	650

	"Alundum" fused alumina No. 1	"Alundum" fused alumina No. 2	"Crystolon" silicon carbide
Barometric pressure	752.8 mm. Hg	736.7	749.6
Volume air used	50.5 cu. ft.	46.8	23.1
Vapor pressure	8.81 mm.	9.32	5.08
Air at meter	33.47°C	32.64	28.6
Manometer	4.0 mm.	4.0	3.0
Calorimeter air (in)	35.46°C	38.42	39.03
Calorimeter air (out)	242.42°C	245.9	313.48
Thickness of test piece	2.54″	2.53	3.54
Temperature of bottom	1250°C	1250	1188
Temperature of top	650°C	650	730

Results

TABLE II

	Coefficient of thermal conductivity (c. g. s. units) Determined	Average
Silica No. 2	0.00089	
Silica No. 3	.00109	0.00099
H. W. fire clay No. 1	.00163	
H. W. fire clay No. 2	.00175	.00169
Pressed fire clay No. 2	.00220	
Pressed fire clay No. 3	.00187	.00203
Light weight fire clay No. 1	.00269	
Light weight fire clay No. 2	.00233	.00251
Sillimanite No. 3	.00448	
Sillimanite No. 4	.00417	.00432
Magnesia No. 1	.00667	
Magnesia No. 2	.00643	.00655
"Alundum" fused alumina No. 1	.00873	
"Alundum" fused alumina No. 2	.00793	.00833
"Crystolon" silicon carbide No. 1	.00982	.00982

For the purpose of comparison there are given below results obtained by others on refractories at high temperatures:

TABLE III[1]

	Temp. interval	Coefficient (c. g. s. units)
Silica	165–1015°C	0.0033 burned at 1300°C
Magnesite	185–915	.0060 burned at 1300
Fire brick	310–1000	.0054 burned at 1300
Glass pot mixture	175–1150	.0029 burned at 1200
Carborundum	420–1000	.0150 burned at 1300

TABLE IV[2]

Silica	0.0020	Temp. interval and temp. of burning
Fire brick	.0034	unknown.
Magnesite	.0071	
Carbofrax	.0243	

TABLE V[3]

	Mean temp.	Coefficient
"Alundum" fused alumina	900°C	0.0068
Sillimanite	900	.0044
"Crystolon" silicon carbide	900	.0235

TABLE VI[4]

	Temp. interval	Coefficient
Silica	700–800°C	0.0035[4]
Magnesite	100–900	.0081[4]
Silica	550–1440	.0040[5]
Magnesite	690–1370	.0091[5]
Silica	850–1350	.00105[6]

Discussion of Results

The relative order of the conductivities of the refractories studied, referred to the pressed fire clay mixtures is, pressed fire clay 1.0; sillimanite 2.1; magnesia 3.2; fused alumina 4.1; silicon carbide 4.8.

The most marked differences between these results and those obtained by others are to be found for silica and fire clay. The average result for silica, 0.00099, is but one-third as much as obtained by Wologdine, and Goerens and Gilles, one-fourth as much as obtained by Doughill, Hodsman and Cobb, and one-half as much as obtained by Linbarger. Similarly, the results for fire brick are noticeably lower. Hepplewhite using an air calorimeter obtained a result, however, which is not so markedly different from that obtained by this laboratory. Hepplewhite, finding his results lower than those of others apparently sought only for a reason to explain

[1] Wologdine, *Electrochem. & Met.*, **7**, 383 (1909).

[2] Linbarger, *Chem. & Met. Eng.*, **19**, 489 (1919).

[3] K. T. Moores, "Thermal Conductivity of Refractories at High Temperatures," M. I. T. Thesis, Norton Library.

[4] Goerens and Gilles, *Ferrum*, **12**, 1–11, 17–21 (1914).

[5] Doughill, Hodsman and Cobb, *Jour. Soc. Chem. Ind.*, **34**, 468 (1915).

[6] Hepplewhite, *loc. cit.*

this discrepancy. The construction of his calorimeter, lateral flow through the test specimen and permeability of the latter to hot gases, as before mentioned, appear to be of more importance than the source of error he has mentioned and these would increase, not decrease his result.

The result obtained for sillimanite is practically identical with that obtained by Moores. However, his result for "Alundum" is considerably lower and that for "Crystolon" higher. Moores' test specimens were burned at cone 12.

No attempt was made to determine the effect of the temperature of burning, the porosity and permeability on the conductivity of refractories. Wologdine in this connection found the conductivity of fire clay, bauxite, and silica refractories to increase materially with temperature of burning. Increasing the porosity of fire clay reduced the conductivity, while increasing the permeability increased the conductivity.

Wologdine further found that the conductivity of fire clay, silica and bauxite increased with temperature, although the increase was small. Moores on the other hand found the coefficient to decrease in the case of "Alundum," "Crystolon" and sillimanite. It would seem that one or the other must be wrong.

A complete check was not obtained upon "Crystolon" silicon carbide. Owing to the failure of the furnace air compressor a few minutes after starting the test, complete data were not obtained. However, those obtained are in fair agreement with the data reported by others.

THE FIRING OF REFRACTORY PRODUCTS IN FRANCE[1]

By R. V. Widemann

ABSTRACT

Importance of the question for a country where fuel is expensive and resources are less than consumption.

Types of Kilns Used.—Principally continuous kilns; some intermittent ones and a few tunnel kilns.

Heating of Kilns.—Heating direct or with gas—evolution of ideas.

Conclusion.—Heating in modern kilns consists in transporting calories from one point to another with the minimum of loss, the hearth serves only to compensate these losses while raising the calories to a higher potential.

The firing of refractory products can be considered either from the purely technical point of view of the influence of the firing temperature on the quality of final product, or from the economic point of view of obtaining this firing temperature in the least onerous manner.

The fuel question plays an important part in the ceramic industry, particularly in the making of refractories; it is one of the important elements in cost of production, especially in a country like France in the present situation.

Our[2] production of coal in 1913 amounted, in round numbers, to 40 million tons; in 1921 due to our coal mines having been destroyed, the extraction was only 28 million tons. In 1920, although our needs amounted to 80 million tons, we were able to obtain, both in French and foreign coals, not more than 50 million tons.

The saving of fuel, undertaken in all of the great nations, presented then and still presents to our country a primordial interest.

The point of these various statements is to show very briefly the technic of firing in the industry of refractory products in France and the evolution of ideas in respect to firing.

Principal Types of Kilns

The kilns used in France are of three sorts: (*a*) intermittent kilns; (*b*) continuous kilns with products stationary and fire moving; (*c*) continuous kilns with products moving and fire stationary.

My general impression, borne out by reading the *Journal of the American Ceramic Society*, is that the continuous furnace is used more in France than in the United States. Our factories are of little importance in comparison but every French factory works with fire moving continuous kilns. The use of kilns of category (*c*) is just beginning to expand, and intermittent kilns are used only for special products.

(*a*) Intermittent kilns.—These in general are rectangular kilns with a capacity varying from 40 to 100 tons; primitively heated with fireplaces and with natural draft. It is not worth while to take up this type of kiln for they present nothing of particular interest. We may mention in passing that the primitive hearth has been replaced by semi-gasifiers; that the mechanical draft tends to replace the draft by chimneys, and that,

[1] Read before the Refractories Division, Pittsburgh Meeting, Feb., 1923. Translated from the French by Frederick G. Jackson

[2] France.

in order to get the best use of the calories, certain installations have a partial recuperation.

This recuperation is brought about in part by enlarging the exit flues to allow the firing of products which do not require a very high temperature and partially by relying on the neighboring kilns to use the heat generated in periods of little firing.

For certain kilns heated with gas, it is even possible to use kilns that are cooling, as recuperators, to heat the air used in the combustion of another kiln.

Continuous Kilns with Products Stationary and Fire Moving.—These generally consist of between sixteen and twenty-four chambers on two parallel lines. The chambers have a capacity of 10 to 20 tons each. Sometimes they are separated by a fixed wall. Sometimes this wall is made of the product to be fired. The uniting of these furnaces into a one-piece body of reinforced concrete gives good results. They make a very flexible plant, each kiln having three to six chambers, and each burning only twenty-four hours. Their operation is more economical as well as easier the more rapidly they are operated.

They are generally heated by one or several gas generators, placed at the end of the kiln, but at certain factories coal is introduced directly through holes in the roof of the kiln. The use of a mechanical method of distributing the coal of the special type as recently described in the *British Clay Worker*[1] or similar types is being built in France.

Continuous Kilns with Products Moving and Fire Stationary.—Although one of the first kilns of this type (Faugeron kiln) has given interesting results, and although these were originated in France, factories using tunnel kilns for refractory products are scarce and all of recent construction.

The characteristics of kilns of this type present nothing of especial interest, having been given very complete publicity in the September, 1922, number of this *Journal*.[2]

Heating of the Kilns

It might be said that the firing of refractory products is a part of the problem of burning in general. In this case it is the most important since these kilns come in the class of high temperature kilns. But if on the other hand lower temperatures do not interest our industries we must not forget that drying plays an important rôle and that in consequence we use low temperatures or, to speak more exactly, great quantities of calories at low potential. The problem of heating ceramic kilns should therefore be

[1] No. 367, November, 1922, page 246.

[2] "Preliminary Report of the Committee on Fuel Conservation on the Railroad Tunnel Kiln," *Jour Amer. Ceram. Soc.*, **5** [9], 602 (1923).

considered not only from the point of view of getting the firing temperature most economically, but also of using the maximum amount of the heat now lost.

In the results published from time to time on kilns one learns in general that firing to a temperature which is not by any means always indicated has been obtained with per cent of a fuel of which perhaps the name is mentioned, but rarely the composition, and less often the calorific value.

In various tests which we have made we can say that in order to fire to cone 13 or 14 the following results expressed in calories per ton of product burned are required.

(*a*) Intermittent kilns.—1,500,000 to 2,500,000 calories according to the dimensions of the furnaces, their age, and the nature of the product fired.

(*b*) Continuous kilns with products stationary with fire moving.—With different methods of heating the number of calories required is from 900,000 to 1,000,000 per ton.

(*c*) Continuous kilns with products moving and fire fixed.—This figure is estimated at 600,000 calories per ton.

Presented in this form these results may at first cause surprise but if you follow this presentation you will see that a continuous kiln of class (*b*) will consume (if there is used the same fuel at 7,000 calories), in heating direct, about 130 kilograms per ton. With gasifiers, about 185 kilograms per ton. This shows the inevitable loss of 25 to 30% due to gasification.

Utilization of Fuel

The economy of fuel being necessary we should look over every possible process of utilization.

A. Direct combustion.
   1. Hand fired grate
   2. Mechanical fired grate
   3. Powdered coal

B. Direct gasification.

C. Preliminary distillation, more or less complete, and utilization of the combustible residue according to (A) or (B).

1. Hand Fired Grate.—The hand fired grate is still in use in intermittent furnaces and in the small factories in general. It is about equally used in continuous kilns of class (*b*), but this use, sufficiently common for ordinary products, is rare for refractory products. A conscientious personnel and a close supervision are necessary in order to give good results.

We have had occasion to visit a factory in which the continuous kiln managed by a good burner consumed 8.7% of fuel with hand firing, but a single operator obtained this result and the other kilns of the same system fired 14 to 15% in order to reach the same temperature.

2. Mechanical Stoking.—A mechanical stoker as used in boiler

practice and in certain metallurgical furnaces, does not seem to have been applied as yet to the heating of ceramic kilns.

3. Powdered Coal.—The producers of refractory wares are hesitating whether rightly or wrongly, about going into the matter of powdering coal on account of the effect that the ashes would have on the ware.

It appears that the idea suggested in the *British Clay Worker* of a direct mechanical distribution of coal in the kiln has a chance of being considered. We know that installations of this nature have been tried in France with a certain success. We realize the advantages of the burning of coal in the very midst of the products to be fired without depending on the handling by workmen. It may be said that in powdered coal lies the possibility of an important simplification of the mechanical installation.

B. Direct gasification.—After having had a great success this system is now losing ground. Actual gasifiers possess a thermic conversion which varies from 70 to 80% and there is a loss of transportation, which cannot be calculated in advance.

In order to use very hot gas it is necessary to have the gasifiers very near the kilns, a thing which is not possible with central batteries of gasifiers, or at least with gasifiers supplying continuous chamber kilns.

In these conditions the actual tendency is to use the gasifiers only when it is desired to have fuel free from elements which might affect the product, or in order to utilize poor fuels impossible to use directly. Studies are being directed to the use in gasifiers of combustibles carrying 50 and 60% of ash.

C. Preliminary distillation.—Distillation, considered from the purely thermic point of view, is also most unjustifiable. This system does not directly interest the ceramic industries, but it should be considered in the interest of general economics, since it makes possible the recovery of by-products. For factories situated in the coal regions the idea of enormous installations for distilling and gasification allows the consideration of the distribution of a poor gas enriched to 1600 to 2000 calories for use in ceramic kilns.

Concluding this brief exposé it is of interest to know that on account of the great dearth of coal in 1920 and the consequent high price of fuel the factories situated in wooded districts have fired their kilns with wood. From results obtained either by firing direct or in gasifiers it is possible to replace one ton of coal by two tons of wood. However, for gasifiers it is advisable to use a mixture of wood and charcoal in equal parts. The use of wood alone would necessitate the altering of the furnaces which were constructed for the gasification of coke or coal.

Conclusions

The firing of refractory products in France is characterized by a large use of continuous kilns with products stationary and fire moving, with a

tendency toward mechanical delivery of fuel directly to the very interior of the kiln.

Intermittent kilns are found only in small factories or for firing special products.

The tunnel kiln with products moving and fire fixed is of great interest from an economic point of view. Well constructed and well regulated, it assures an excellent utilization of the calories contained in the products during cooling for the drying operation (an important quantity of calories of low potential) and in part for the firing itself to heat the primary or secondary air to a higher temperature.

The hottest part of the kiln, of relatively small dimensions, may be carefully insulated so as to reduce losses by radiation to a minimum. The weak point of the combustion is that it serves only to recover a part of the calories from the cooling zone at a potential necessary to obtain the firing at the temperature desired for the products under consideration.

The utilization as completely as possible of the calories of the fuel is the goal of every industry. In an appreciation of the value of a kiln should be considered not only the conditions of reaching the proper firing temperature but also the advantages which it presents, of furnishing calories for other operations such as drying or preheating.

We are at this moment in a period of transformation which will doubtless not yet provide the ideal solution from the ceramic point of view but which will represent in every case an improvement and which will contribute very certainly to the progress of the problem of industrial heating in general.

PARIS, FRANCE

HIGH TEMPERATURE LOAD AND FUSION TESTS OF FIRE BRICK FROM THE PACIFIC NORTHWEST IN COMPARISON WITH OTHER WELL-KNOWN FIRE BRICK[1]

By Hewitt Wilson

ABSTRACT

Seventeen samples of fire-clay brick from the Pacific Northwest have been tested with twenty-seven other commercial brands of fire clay, silica, magnesia, chromite, zirconia, diaspore, silicon carbide and crystalline alumina, as well as china clay and crystalline sillimanite products made at the University of Washington. The tests show that the fire-clay brick of the Pacific Northwest vary considerably in quality. According to the high temperature load test, the majority of the local brick are among the upper grades, some are to be classed with the best fire-clay brick and one equal to the best diaspore brick. The brick tested is not the best which can be made from Pacific Northwest materials, for the kaolins in eastern Washington and northwestern Idaho give opportunity for the production of an all-kaolin fire brick.

A method is suggested for testing *super-refractory* materials under load at high temperatures similar to the standard load test for fire clay and silica brick except that the temperatures are measured by cones, and are raised until 10% linear deformation of the brick is obtained. The rate of heating and soaking varies with the brick under test, and the principles learned from the cone fusion test are used in the application of heat. A numerical value, expressing the area under the cone-shrinkage curve, affords an easy method for comparing the high temperature load resistance of various refractories.

The brick which are best able to resist deformation at high temperatures are composed of crystalline materials which have developed a recrystallized bond of the same composition. These are crystalline silica, silicon carbide, corundum and sillimanite, and they resist deformation at temperatures close to their melting points. Amorphous materials like fire clay, diaspore, bauxite or even the very refractory crystalline materials like chromite and periclase, which depend on amorphous silicates for a bond or are contaminated with silicate impurities, will fail with the softening of the bond of the amorphous impurities. The cone fusion of the brick as a whole can not be depended upon to indicate the resistance to load at high temperatures.

Introduction

Although the present Pacific Northwest brick are good, they are not the best that can be made from local materials. They are probably the best that can be made and sold for the present prices, but when the demand comes for a superior article the kaolins of the Inland Empire, in eastern Washington and northwestern Idaho, can be washed and made into brick which will equal any *fire-clay* brick now being manufactured. Four companies are now using the run-of-mine kaolin without washing, their refractoriness being low because of the quartz, mica, and other impurities.

The purification and subsequent changed process of manufacture will not necessitate installation of expensive equipment.[2] Purification by water is slow and requires considerable water, which is not available in large quantities in all parts of the Inland Empire, but for some beds a dry

[1] Received October 25, 1923.

[2] A. S. Watts, "Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian Region." Bureau of Mines, *Bull.* **53** (1913).

process can undoubtedly be devised, whereby the majority of the impurities can be removed. The long dry spell in the summer time affords opportunity to dry by the "field" system, but the modern filter presses can be used for more rapid work.

A suggested dry process consists of (1) thoroughly drying the clay, (2) a coarse disintegration through toothed or spaced rolls, (3) a fine disintegration in a high-speed, fan-type disintegrator which is now used in pottery and tile plants and followed by (4) air separation of the quartz and coarse mica from the kaolin. Some fine quartz and mica will be carried along with the kaolin. The air separation method is now in use in the diatomaceous earth plants of Washington and is a common method for other materials. Whether the purification is made by water or air, it will be necessary to either calcine part of the kaolin for grog or replace a portion of the quartz to control shrinkage and cracking. In some of the clays white mica is the chief fluxing impurity and very careful flotation is required to separate it from the kaolin.

In all the tests, standard pyrometric cones were used as indicators of heat treatment. For the fusion test the bricks were sampled after the load test.

Before sampling, each brick was cleaned of all adhering matter by grinding on an emery wheel. The samples were ground to pass a 60-mesh sieve, molded with gum and fired with the standard cones in an oxygen-acetylene furnace.[1]

In case the brick had softened considerably in the load test, the cone fusion may be appreciably lower than that of a fresh specimen.

In Fig. 1, the two full heavy lines represent the maximum and minimum pyrometer readings obtained for the respective cones in the load test kiln. The dotted lines join Brown and Murray's results for fast heating of cone 9[2] to Kanolt's data[3] beginning at cone 26. The small circles beginning at cone 26 show the temperatures found for cones 26 to 38 fired in the oxygen-acetylene cone fusion furnace. With the exception of those below cone 30, they compare very well with Kanolt's figures.

High Temperature Load Tests

The present test for siliceous fire-clay brick under load at high temperatures, proposed by the American Society for Testing Materials,[4] consists

[1] Hewitt Wilson, "An Oxygen-Acetylene High Temperature Furnace," *Jour. Amer. Ceram. Soc.*, **4**, 835 (1921).

[2] G. H. Brown, and G. A. Murray, "Function of Time in the Vitrification of Clays," *Trans. Amer. Ceram. Soc.*, **15**, 213 (1913).

[3] C. W. Kanolt, U. S. Bur. Stand., *Tech. Paper* **7**, 15 (1911).

[4] Standard test for refractory materials under load at high temperatures, "designation," C 16, adopted by the A. S. T. M. in 1920. See *Year Book*, Amer. Ceram. Soc., 36, 37, 47–51 (1921–22).

of heating the standard nine-inch brick, standing on end and loaded to 25 pounds per square inch, to 1350°C in four and one-half hours. After holding this temperature for one and one-half hours, the furnace is cooled and the brick measured for contraction. The brick shall not show a contraction of more than 4% of the original length. Silica brick are carried to 1500°C in a similar manner.

Many of the present higher grade refractories will easily stand this test, and, therefore, it does not clearly distinguish between their relative softening behaviors. 1350°C is far too low a temperature for testing superrefractories used in service above 1600°C. Increasing the load to cause failure at 1350°C also will not indicate the behavior of the brick under light loads at 1600°C. For service at 1600°C, the brick should be heated

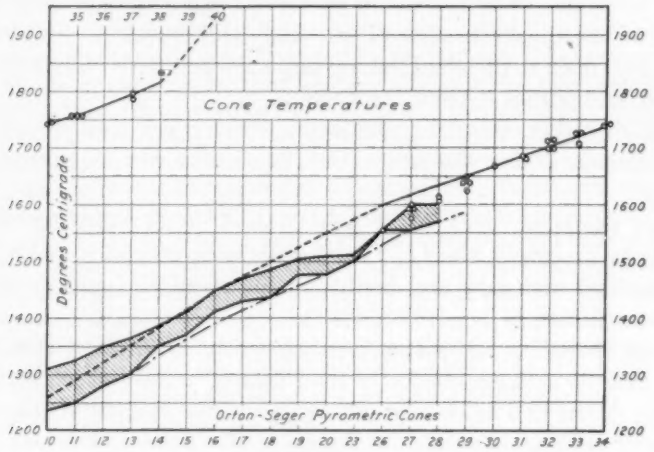

FIG. 1.

to 1600°C or higher, under the same or slightly higher loads than those to which they will be subjected in service.

The method used for this investigation consisted of heating the brick, standing on end and subjected to a load of 25 pounds per square inch to an increasing temperature, until a contraction of 10% was reached. The expansion and following contraction were measured by a screw gage attached to the leveling mechanism of the loading beams. The furnace is very similar to that suggested by the American Society for Testing Materials. The temperatures were measured by both pyrometric cones and a new Leeds and Northrup optical pyrometer. As soon as the brick started to shrink, the temperature was held until most of the shrinkage at that temperature or cone had been eliminated. In an 8 to 10-hour test, it is not possible to take out all the shrinkage at each cone, but it is possible to bring the rate of shrinkage down to a low figure.

The expansion of the furnace was calibrated with two Refrax (silicon carbide) brick whose coefficient of expansion and contraction was taken as 0.0000065 at cone 12 plus. The per cent expansion and contraction were plotted against cones. An accompanying chart gives the temperatures found for each cone.

Rate of Firing.—The rate of firing should be so regulated that each cone requires at least 30 minutes for deformation. When the shrinkage is rapid, 60 minutes per cone is better. The heat penetrates to the center of the cones, a distance of $^1/_4$ inch, more quickly than to the center of a brick, a minimum distance of which is 1.25 inches. A fast rate of heating will deform the cones but have small effect on the brick and thus will give a higher load value than a slower rate of heating.

We do not believe that it is practical to establish a single rate of heating for all kinds of fire brick. A better plan is to heat fast to 1100°C for the average fire-clay brick or 1200°C for the aluminous variety or super-refractory materials and then retard the rate of heating to about two cones per hour until the shrinking period is reached. At this point, no advance in temperature should be made until a quiescent period in the deformation of the brick is attained. Thus the time-shrinkage curves should show short pauses or a stairstep effect. This is the same treatment sought for in the ordinary cone fusion test. In order accurately to place an unknown cone in the Orton-Seger cone scale, it is necessary to "soak" the heat to the centers of the cones rather than use a surplus of heat. The curves given in the accompanying charts have been copied from the time-temperature-cone-shrinkage curves plotted during the test runs, but all have been reduced to the same cone-shrinkage basis.

High Temperature Load Value.—A numerical value was assigned to each brick as a method of estimating the relative resistance to the load at high temperatures. This value is the area in square inches under the horizontal zero shrinkage line, and under and to the left of the shrinkage curve of the brick down to 10% shrinkage. The load value increases with the cone temperature at which the brick can sustain the load, is lowered by an early shrinkage and does not include the expansion area above the zero shrinkage line. When the curves are plotted on inch cross-section paper (20 divisions to the inch) the areas can be computed easily without the aid of a planimeter. We used the ratios: one inch equals four cones (horizontal) and 4% shrinkage (vertical).

Thermal Expansion.—In each test the lever arm, by which the load was applied to the brick, raised as the furnace was heated to cone 10. With the better grades of refractories, this increase was greater than that determined for the thermal expansion of the furnace bottom and loading mechanism. Two reasons can be given for the low or zero expansion of some of the poorer grades of brick. The refractoriness may be so low

that the brick deforms from fusion as fast as the furnace expands. In other cases the refractoriness may be satisfactory but the original firing in the manufacturer's kilns may have been so low that all the firing shrinkage is not out of the brick. Thus, in the case of the clay and aluminous types of fire brick, except the very siliceous ones, a medium or high thermal expansion is a good indication of refractoriness and good firing.

Type of brick	Per cent thermal expansion	Type of brick	Per cent thermal expansion
Clay	0.00 to 0.63	Chromite	1.20
Siliceous clay	0.00 to 0.86	Magnesia	2.20
Kaolin	0.75 to 1.11	Zirconia	0.52
Aluminous	0.48 to 1.53	Crystalline alumina	1.65
Recrystallized sillimanite	1.10	Silica	2.42

It is noted in the first four types that the per cent expansion increases with the load-carrying ability of the brick from the ordinary clay to the high aluminous varieties

Testing Results

In Table I the refractories have been arranged in numerical order according to their high-temperature load-test values. A commercial recrystallized silicon carbide brick and a recrystallized sillimanite brick made in our laboratory both gave no shrinkage at cone 33, or a load value above 11.8. These were followed by a commercial crystalline alumina brick (11.2) which we refired to raise the load-test value from 9.3 and a commercial silica brick (10.62) composed of recrystallized cristobalite and tridymite. Below these lie the high aluminous brick made from diaspore or bauxite with load values ranging from 4.21 to 9.38 and the high fired kaolin brick with load values from 6.75 to 8.12. The commercial fire-clay brick have a maximum value near 5 and range from there to below 1.00. The largest number lie between 2 and 4. Commercial chromite and magnesia brick gave values of 3.8 and 4.31, respectively.

When grouped into several classes as shown in Table II, it is noted that the load-test values do not correspond with the cone of fusion or with the relative temperatures at which shrinkage starts. The load-test values correspond better with the relative temperatures at which fast shrinkage starts or the cone-temperatures at which 10% shrinkage is reached.

The two main exceptions to the load-test cone-fusion agreements are:

(1) The case of a refractory flint fire clay bonded with a poorer grade of plastic clay. Bleininger and Brown[1] in 1910 pointed out that a fire brick under load at furnace temperature is no better than its bond, which lubricates the coarse particles of refractory flint clay so that the mass

[1] A. V. Bleininger, and G. H. Brown, "Behavior of Fire Brick under Load Conditions," *Trans. Amer. Ceram. Soc.*, **12**, 341 (1910).

softens with the partial fusion of the bond clay. In making the cones for the fusion test, standard practice[1] requires that the sample be ground to pass a No. 60 sieve. In this manner the flint clay raises the fusion point of the mixture to somewhere near the arithmetical average of the two clays. In the load test the brick slumps with the lower refractory clay.

A recent study[2] of 86 of the best Ohio fire clays showed that only 16 had cone fusion points above cone 31. Twelve of these were flint clays. Cone 33 was the highest cone fusion point. Only two bond clays gave fusion points equal to cone $30^1/_2$ and some ranged as low as cone 23.

(2) A second case is similar to the first. Chromite, magnesia, diaspore, alumina, and sillimanite brick all have very high fusion and melt-

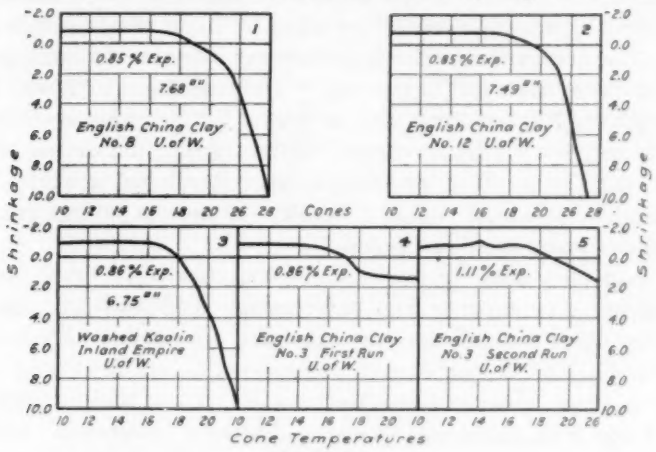

FIG. 2.

ing points. Commercial brick made from these materials are usually mixed with plastic fire clays for bonding or as in the case of the chromite and magnesia brick they contain natural silicate impurities which act as high temperature lubricants for the refractory grains and cause early failure.

The silica, silicon carbide and recrystallized sillimanite brick were the only ones which maintained resistance to load close to their fusion or melting points. They are composed of interlocking crystals, not merely a loosely knit structure of crystalline grains, but new crystals have actually grown between the crushed grains during the firing of the brick and bind the whole mass into a strong structure. All the amorphous materials tested show early shrinkage and deformation as low as 23 cones below their fusion point.

[1] Amer. Ceram. Soc. and the A. S. T. M.

[2] "Coal Formation Clays of Ohio," Ohio Geol. Surv., *Bull.* **26** (in press).

Individual Test Results

Nos. 1, 2, 4, 5. English china clay brick. The washed china clay from Cornwall, England, is a well-known standard material for use in porcelain and china whiteware bodies and for glazes. While approaching the theoretical kaolinite proportions of alumina and silica, analysis shows that this china clay contains a relatively large percentage of lime which is a most active high temperature flux. The cone fusion point is therefore cone 34 plus, instead of cone 35.

The raw English china clay was molded into rough brick and fired to cone 26. These were crushed and ground so that 50% passed a 2-mesh screen and was caught on a 4-mesh. Forty per cent was ground to pass a 20-mesh screen. These proportions were found by experiment to give the densest brick which could be packed by hand tamping in a steel slip mold. The fine material fills the interstices between the large grains and does not elbow them out of position. The remaining 10% was the raw, weakly plastic English china clay to which 0.2% of gum arabic had been added to increase its dry strength. After molding and drying, the bricks were fired to cone 26 at which heat they developed a white, vitreous, porcelain-like structure, though, because of defects of molding, the interior shows many blebs and holes.

The load tests indicate that the English china clay brick prepared in this manner give superior high-temperature load-resisting properties to any of the other common fire-clay brick and are inferior to only one other clay sample (No. 40), an eastern commercial kaolin brick and which we believe is made in a very similar manner. These kaolin brick surpass most of the high aluminous (bauxite, diaspore) commercial brick which have higher cone fusion points. The china clay brick were probably fired to higher temperatures and most of the commercial aluminous and clay brick contain bond clays inferior to the china clay. A pure grade of diaspore or bauxite, treated in the same manner, gives better brick than the china clay. (See Nos. 41 and 51.) In the load test, the brick will fail with the bond clay which, if inferior to the flint clay, alumina, etc., acts as a lubricant to the more refractory grains. We found that by experiment, poor molding and unbalanced grain sizes will give china clay brick which fail by shearing under load at cone 18–20.

No. 1. Sample expanded 0.85% of its original length, and maintained this to cone 17, after which it shrank gradually to cone 23 and then more rapidly at higher heat treatments reaching 10% shrinkage at cone 28. The area under the curve and the 0.0 line is 7.68 square inches which is a relative value indicating the load-resisting qualities at high temperatures.

No. 2. This English china clay brick gave a linear expansion of 0.85%, which was maintained to cone 17, but it shrank faster than did No. 1 and

reached 10% shrinkage at cone 27 plus. The high temperature load value is 7.49 sq. in.

Nos. 4 and 5. These two load tests were obtained from the same brick. In the first the temperature was only raised to cone 23 and because of the failure of the alundum plunger which applied the load, the test was discontinued. After the second test to a maximum of cone 26, the brick had only shrunk a total of 4.85% for both tests. This is but 0.85% above the allowable maximum in the American Society for Testing Materials' load test for heavy duty fire brick at 1350°C (cone 14 approximately).

No. 3. The kaolins of eastern Washington and northwestern Idaho are similar to the English china clay. The original material in both fields requires the removal of quartz, mica, and some feldspar. The Inland

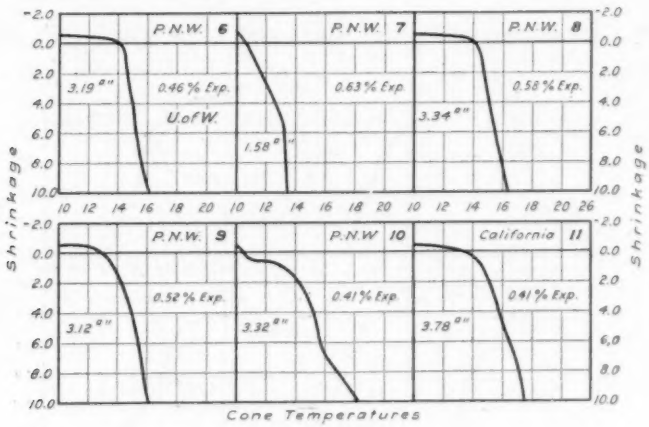

FIG. 3.

Empire kaolins provide a supply of raw material for a future whiteware pottery industry.[1]

At the present time, the run-of-mine kaolin material is used in the manufacture of siliceous fire-clay brick at four factories. Test No. 3 (University of Washington brick) gave a load test but slightly inferior to the best of the English china clay brick and superior to most of the other fire-clay and high aluminous commercial brick. The Inland Empire kaolins, therefore, offer the opportunity for the production of the highest quality fire-clay brick.

It is not expected that the quantity of such brick will be great for the manufacturing costs will be high, but a few should be made to meet the

[1] H. Wilson, A. L. Bennett, and F. T. Heath, "Preliminary Report on the Residual Kaolin and Feldspar in the Pacific Northwest," *Jour. Amer. Ceram. Soc.*, **6** [3], 475 (1923).

special demands for a superior article. A few such brick in the hottest parts of the furnaces with the ordinary brick for the remainder will give a more uniform life to the furnace wall, will prevent shutdowns to renew but a small portion of the wall, will make it unnecessary to send east for the high aluminous (diaspore) brick, mortars and patching compounds, and will give the manufacturer a better chance to sell his ordinary product for the rest of the job.

No. 6. A brick made at the University of Washington of the ground fire clay from a Pacific Northwest company. It was fired about three cones higher than the usual commercial product, and, as a result, the high-temperature load value was doubled. After the load test the brick shows a blackened interior which has developed a vitreous and brittle structure. Maximum expansion, 0.46%. High-temperature load value, 3.19.

No. 7. A commercial Pacific Northwest brick which fails under load

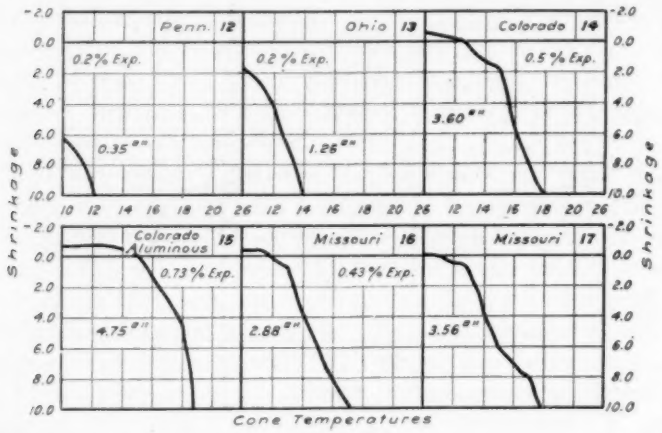

FIG. 4.

before cone 14 and develops a blackened vesicular structure at cone 16. Maximum expansion, 0.63%. High-temperature load value, 1.58.

Nos. 8, 9, 10 are commercial siliceous Pacific Northwest brick which gave similar load tests. The break in the curve of No. 10 at cone 10–11 is probably due to a low firing in the manufacturer's kilns. After this shrinkage is eliminated, the brick maintains considerable rigidity. Early shrinkage does not always indicate early failure. The quartz content of the siliceous brick keeps the body open and porous after heat treatment to cone 18.

No. 11 is a commercial California siliceous brick in which the quartz particles are surrounded by a high-grade fire clay instead of a kaolin-mica mixture.

No. 12 is a commercial brick made of a Pennsylvania flint fire clay bonded with an inferior bond clay which fuses and develops a vesicular structure at a very low cone. The brick had already shrunk over 6% at cone 10. The maximum expansion is also low as the shrinkage started before the usual expansion of the furnace was complete.

No. 13 is likewise an example of the poor load carrying behavior of an Ohio flint clay bonded with an inferior bond clay.

No. 14 appears to be a mixture of two or more clays, some of which are refractory and white-burning, and others are fused, blackened and vesicular at cone 18. Black slag spots oozed out on the surface of the brick. The brick tested were from Colorado.

No. 15 is one of the commercial aluminous brick from Colorado which has maintained an open porous structure and shows no signs of fusion or

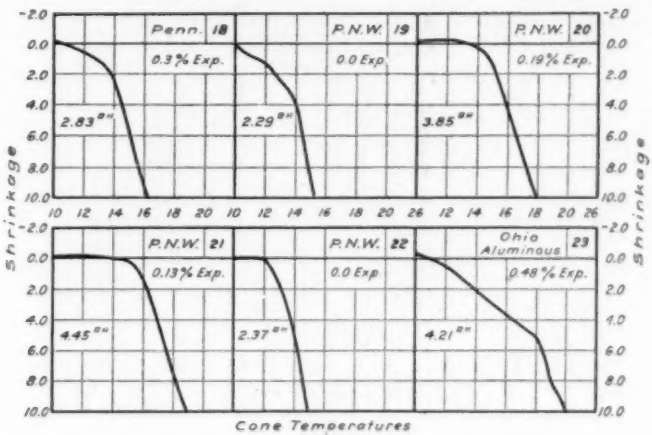

FIG. 5.

sintering to the eye on the fractured surfaces and yet has shrunk 10% in length and, in some cases, shows curved edges and deformation of shape due to shrinkage when partially soft. The very high fusion point (cone 37) indicates that the refractoriness has not been severely tried at cone 19. The load-test values of this type of material will vary with the original temperature of firing in the manufacturer's kilns, unless a low-fusing bond clay is used. However, brick in which an interlocking crystalline framework has developed, are the only ones which we have found yet, which will resist loads up to their cone fusion or melting temperatures.

Nos. 16 and 17 are examples of the better grades of fire clay which fire to a dense structure at cone 18–19. No. 16 is composed almost entirely of one type of clay and contains iron compounds which fuse to black slag spots on reheating. No. 17 apparently is formed of two kinds of fire clay, one of the plastic bond type and the other of the flint type.

No. 18 is a well-known commercial brand consisting of coarse particles of Pennsylvania flint fire clay bonded with a less refractory plastic fire clay. The latter is the deforming member of the mixture and prevents the brick from reaching a higher class in the load test.

No. 19 is a commercial product made from one of the light-colored siliceous clays and contains a few dark-colored iron spots. Shrinkage started before the furnace parts had reached their maximum expansion and no apparent expansion of the brick was therefore noted, This early shrinkage is undoubtedly caused by underfiring. The early final shrinkage is due in part to the rupture of the brick along planes caused by auger and die lamination. The brick has not been repressed.

Nos. 20 and 21 are examples of the siliceous light-colored brick which contain but little flux. The expansion of the quartz tends to counteract the

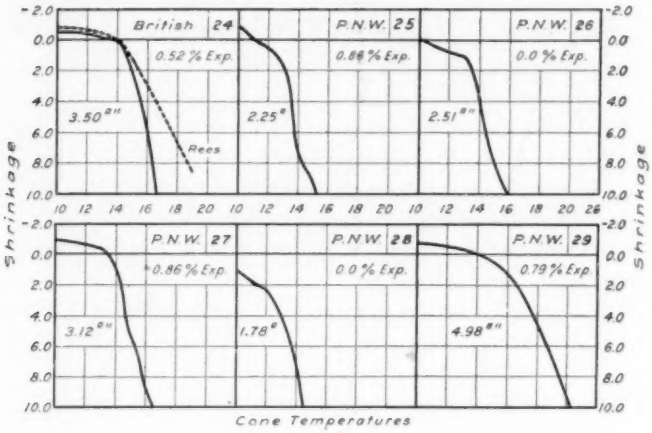

FIG. 6.

shrinkage of the kaolin-like clay bond. After the refiring in the load test, the brick have a punky structure, quite different from the non-siliceous vitrifying type of fire clay.

No. 22 is composed of a single fire clay which does not give a very good load test value due both to a low initial temperature of firing and to early vitrification and fusion. In this load test the brick was carried to cone 23 although it reached 10% shrinkage at cone 15. At cone 23 the sample was bloated and vesicular.

No. 23 is a commercial brick consisting of Missouri diaspore bonded with an Ohio bond clay. The initial firing temperature has not been sufficient to prevent an early shrinkage but when this has been eliminated the brick did not reach 10% shrinkage until nearly cone 20. Its refired structure is much denser and more nearly vitrified than the other aluminous brick.

No. 24 is a sample of a British fire clay brick. It is not a mixture of flint and plastic fire clay but two or more similar fire clays may have been used in the batch. It reached 10% shrinkage before cone 17. The load was removed at cone 20 and, as its companion in the load test was a silica brick, it was carried to cone 31. At this temperature the British brick had softened to an irregular fused mass five inches high. The dotted curve shows a similar load test reported by W. J. Rees of the Sheffield University, England. The thermal expansion obtained by Dr. Rees is 0.8%.

Nos. 25, 26, 27, 28, and 29 are all commercial Pacific Northwest siliceous brick varying in firing treatments, quartz contents and impurities. No. 29, with a load test value of 4.98 is remarkable because of the comparatively low cone fusion (31 plus). This load test value is in the present aluminous

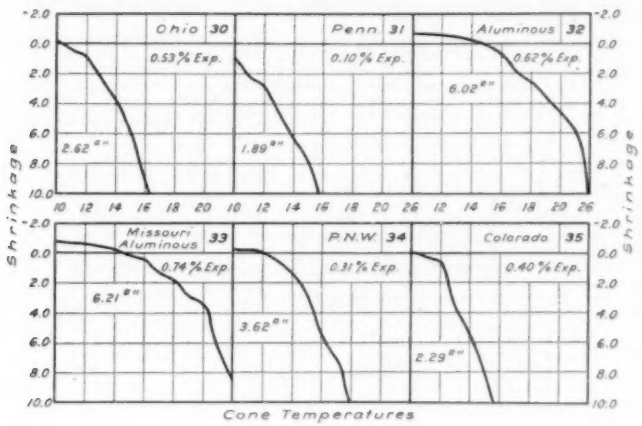

FIG. 7.

refractory class. We believe that this result is obtained by a combination of a high-kaolin content plus a high temperature of firing. A few quartz grains are noted in the broken cross-section.

Nos. 30 and 31 are commercial brick made from eastern flint fire clays and plastic bond clay mixtures. The flint fire clays are very refractory but the bond clays are inferior. The latter deform under load and lubricate the coarse particles of flint fire clay so that the whole mass slumps easily. However, the cone fusion temperatures lie between cones 32 and 33. When ground to pass a 60-mesh sieve the average cone fusion of the two clays is found. A. V. Bleininger in 1912,[1] suggested the use of the minimum amount of plastic bond clay and also the grinding of the plastic bond clay with some flint clay to improve the refractoriness of the former.

[1] "The Testing of Clay Refractories, with Special Reference to their Load Carrying Capacity of Fur. Temps.," U. S. Bur. Stand., *Tech. Paper* **7**, p. 11.

The development of the plasticity of a flint fire clay was increased by wet-pan grinding.[1]

Nos. 32 and 33 are two examples of the aluminous brick made from Missouri diaspore and fire clay. While made by two different companies the load test values are very similar. See Nos. 15 and 23.

No. 34 is another Pacific Northwest kaolin-like brick similar to No. 29.

No. 35 is a mixture of several clays from Colorado, some of which produce fusible iron slag spots. One fires to a dense vitreous gray body, like a flint fire clay and another to a more open buff structure.

Nos. 36 to 39 are four commercial fire-clay brick, two from the Pacific Northwest and two from Sweden.

No. 40 is an eastern commercial kaolin brick probably made in a manner similar to that described for the English china clay brick (Nos. 1, 2, 4, 5).

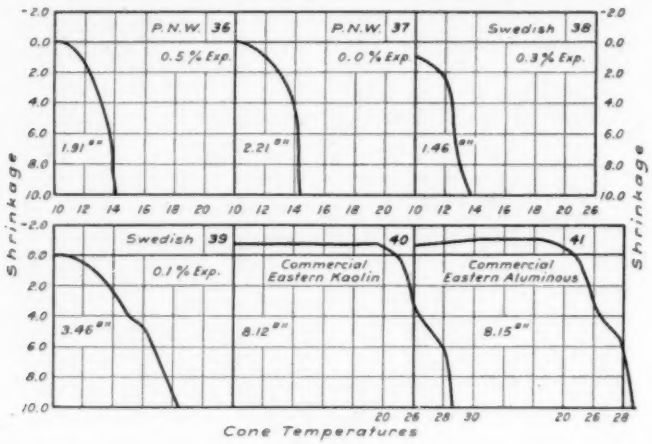

FIG. 8.

It gave the best load test of any clay brick and exceeded all but two of the aluminous variety. Its high temperature rigidity is due to a combination of refractory bonding and an initial high-temperature firing.

Nos. 41 and 51. Show the load tests of commercial high-aluminous brick which have been well bonded and fired to high temperatures.

No. 42. Chromite brick. While the maximum expansion for any fire-clay brick was 0.86%, the chromite brick had an expansion of 1.3%. Curve No. 1 shows the load test behavior of the chromite brick as received from the manufacturer. Curve No. 2 shows the test repeated for another chromite brick which was reheated to above cone 30 for over 12 hours. This high temperature soaking treatment increased the load carrying value of sillimanite brick by producing an intergrowth of crystals between the

[1] See E. F. Goodner, "Four Typical Refractory Clays of Washington," Thesis, University of Washington.

crushed sillimanite grains. Some such result has started with the chromite brick but it contains too much silicate impurity to resist crushing under light loads beyond cone 18–19. The more easily fusible silicates soften and lubricate any crystalline or amorphous refractory grains and easy separation follows. The brick of test No. 1 is friable and the grains are loose. The brick of test No. 2 is much harder and while it sheared in several planes, the broken pieces adhered together very strongly, showing that some portion had fused but had hardened again on cooling. Chromite brick shear along a diagonal plane suddenly and behave quite differently from the amorphous clay brick whose length diminishes while the cross-section increases. The cone fusion point of the chromite brick is above cone 42.

No. 43. Magnesia brick. Curve No. 43 shows the high temperature load test of a commercial brick made in the east from Washington

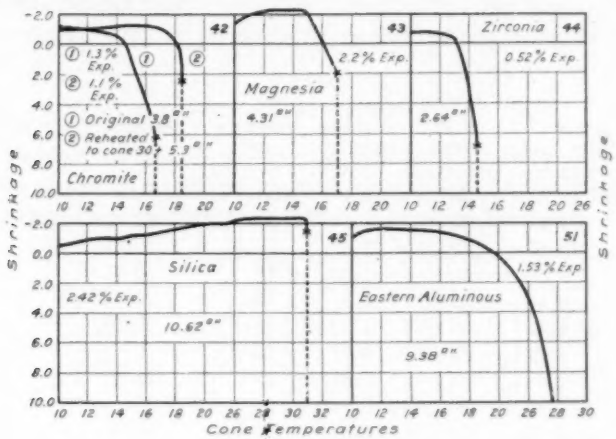

FIG. 9.

magnesite. The brick expands to 2.2% which is reached at cone 13 and maintained to cone 15. After only 4.2% contraction, the brick shears suddenly at cone 17 in a similar manner to the chromite brick. While no softening of the larger magnesia grains has occurred, the iron-alumina-lime-silicate impurities have fused and lubricated the interior structure of the brick. One of these magnesia brick was reheated with the chrome brick to above cone 30 to improve the load carrying ability at high temperatures. The magnesia brick standing on end gave way under its own weight during the soaking period, and parts which came in contact with the high aluminous clay lining of the furnace fluxed the latter very badly. The edges of the brick were curved and vertical cracks opened up showing clearly that the brick had softened.

No. 44. Zirconia brick. While pure zirconia has a melting point in the neighborhood of 2900°C, this commercial brick apparently contains too much silicate impurities or added bonding clay to give a high-temperature load test above a lower grade of fire-clay brick. The brick sheared after a contraction of 7% between cones 14 and 15. The cone fusion point indicates a very refractory material. A reheating test was tried on another zirconia brick. However, it was necessary to remove the zirconia brick from the furnace when cone 30 was first reached owing to the bloating and fusion. Gases formed within a vitrified surface have bloated the brick and have produced a very pronounced vesicular structure.

No. 45. Silica brick. Figure 45 shows the load test curve of a well-known eastern brand of silica brick. A previous test on two other brick to cone 28 followed this curve and gave no shrinkage. Because of the rapid volume changes, the cooled brick were punky but they were able to carry the 25 pound per square inch load to very high temperatures. The curve given shows a sudden failure by shearing at cone 31 after a maxi-

TABLE I

Number	Load test value	Cone fusion	Per cent maximum expansion	Start of shrinkage cone	Start of fast shg. cone	10% shrinkage cone
50	Above 11.8	Dissociates	0.84	Above 33	..	..
49	Above 11.8	39	1.1	Above 33	..	..
47 (2)	11.2	39–40	2.0	29 (+)	30	32 (+) (shear)
45	10.62	32–33	2.42	30–31	30–31	31 (+) (shear)
51	9.38	40	1.53	15	20	28
47 (1)	9.31	39–40	1.3	23	23	31 (shear)
41	8.15	38 (+)	1.12	19	20–23	28–29
40	8.12	33⅓	0.75	19–20	23	28–29
1	7.68	34 (+)	0.85	17	23	28
2	7.49	34 (+)	0.85	17	23	27 (+)
3	6.75	34	0.86	16 (+)	18	26
33	6.21	37	0.74	12	20	26
32	6.02	35	0.62	12–13	18	26 (−)
42 (2)	5.3	42	1.1	16	18 (+)	18–19 (shear)
29	4.98	32	0.79	10	16	20 (+)
23	4.96	35	0.32	12–13	14	20–23
15	4.75	37	0.73	13	15	19
21	4.45	30	0.13	13	15	19
43	4.31	..	2.2	15	15	17 (shear)
27	4.23	30–31	0.86	10	13–14	26
20	3.85	30	0.19	12	15	18 (−)
42 (1)	3.80	42	1.3	10	14–15	16–17 (shear)
11	3.78	28–29	0.41	10	14	17–18
34	3.62	31 (+)	0.31	11	13	18
14	3.60	30–31	0.5	10	15	18
17	3.56	32	..	10	13	18 (−)
24	3.50	31 (−)	0.52	10	14	16–17
39	3.46	33 (−)	0.10	11	12	18 (+)

8	3.34	31	0.58	12	14	16–17
10	3.32	31	0.41	10	13	18 (+)
6	3.19	30 (+)	0.46	11	14	16
9	3.12	31	0.52	11	13	16
16	2.88	31	0.43	11	13	17 (+)
46	2.87	Above 42	0.06	14	14	14–15
18	2.83	32	0.3	10	14	16 (+)
44	2.64	37	0.52	11	13	14–15
26	2.62	29 (+)	0.0	10	13	23
30	2.62	32 (+)	0.53	Before 10	12	16 (+)
22	2.37	28 (−)	0.0	12	12	15
19	2.29	30	0.0	10	12	15 (+)
35	2.29	30–31	0.40	Before 10	12	15–16
25	2.25	30 (+)	0.86	10	12	15 (+)
37	2.21	30	0.0	10	12	14 (+)
36	1.91	28–29	0.5	10	11	14
31	1.89	33 (−)	0.10	Before 10	10	15–16
28	1.78	28	0.00	Before 10	12	14–15
7	1.58	27 (+)	0.63	10	10	13–14
38	1.46	28	0.30	Before 10	12	14 (−)
13	1.26	30 (−)	0.20	Before 10	10	14
12	0.35	28 (−)	0.20	Before 10	Before 10	12 (+)

mum expansion of 2.42% which was not reached until above cone 26. All of the other brick preceding the silica brick have deformed under load far below their cone fusion points. The silica brick has the ability to

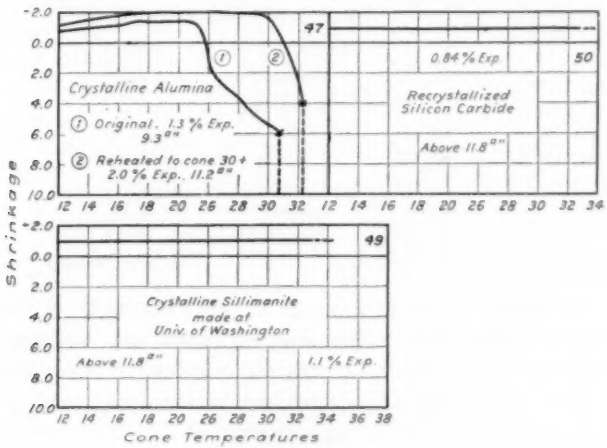

FIG. 10.

maintain a rigid load carrying structure to within 1–2 cones of its softening point under no load. This property is characteristic of pure crystalline materials which do not gradually soften but melt suddenly at a definite temperature. Commercial silica brick contain only 5 to 6% of cal-

cium-alumina-silicate impurities and the original quartz crystalline fragments have been partially recrystallized and bonded with the intergrowth of tridymite and cristobalite crystals. While the final melting point is comparatively low, silica brick are the only brick which have been used successfully in carrying the loads of long flat arches for high-temperature furnaces such as the open-hearth steel furnace. This would indicate that if higher temperatures beyond the melting point of the silica brick are needed, it will be necessary to produce another recrystallized refractory from the group of super-refractories.

No. 47. Crystalline alumina. Curve No. 1 shows the load heat test of a commercial crystalline alumina (corundum) brick, as received from the manufacturer. After a maximum expansion of 1.3% from cones 17 to above cone 20, the brick shrunk rapidly to cone 26 and then at a slower rate to nearly cone 31 where it failed by shearing. In the neighborhood of cone 26 the formation of sillimanite is rapid and this would retard the shrinkage. The silicates of the bonding clay would unite with the finely ground corundum to form sillimanite. On reheating another sample of this brand to above cone 30 a better load-test curve was obtained. The greater expansion (2.0%) which persists to cone 29, shows that a partial crystalline intergrowth has been produced. Apparently the quantity of impurities is sufficient to cause a failure by shearing before that of a relatively pure sillimanite brick.

TABLE II

Class	Load value	Cone of fusion	Start of shrinkage cone	Start of fast shg. cone	10% shrinkage cone
1	Undeformed	( )–39	Above 33	.....	.....
2	Above 10	32–40	29–31	30–31	31–32
3	5–10	32–42	10–18	14–23	18–31 (−)
4	4–5	30–37	10–15	13–15	17–26
5	3–4	28–42	10–12	12–15	16–18
6	2–3	29–32 (+)	Before 10–14	12–14	14–23
7	–2	27–33 (−)	–10	Before 10–12	12–(15–16)

No. 49. Crystalline sillimanite made at the University of Washington. This material was made by melting English china clay and pure alumina in the electric furnace. The recrystallized sillimanite brick were able to carry the load to above cone 33 without any shrinkage or signs of deformation. The plastic bonding material consisted of 10% of a mixture of raw china clay and alumina in the proportions to produce sillimanite, with 0.2% gum arabic.

No. 50. Crystalline silicon carbide. This is the load test of a commercial brick composed entirely of SiC. The silicon carbide is made by heating silica and carbon in an electric resistance furnace. The brick are molded by aid of an organic bond and fired in a second electric resistance

furnace to very high temperatures so that the crushed crystalline fragments are locked together with a growth of new crystals. We are not able to cause failure of this brick after heating to cone 33, although under oxidizing conditions small samples of silicon carbide are dissociating very rapidly accompanied by bubbling at 1650°C.

No. 51. See No. 41.

NOTE: We wish to acknowledge the help received from members of the U. S. Bureau of Mines Experiment Station staff in preparing the sillimanite brick, and to F. W. Schroeder and H. C. Fisher, "fellows," University of Washington, for assistance with the load tests.

DEPARTMENT OF CERAMIC ENGINEERING
UNIVERSITY OF WASHINGTON

THE MANUFACTURE OF AN INSULATING BRICK FROM DIATOMACEOUS EARTH

By C. A. Smith

ABSTRACT

Development of an Insulating Brick.—Pulverized diatomaceous earth was blended with each of the four clays, Tennessee ball, Bedford shale, Rock Hill, Tionesta, in percentages of 0, 5, 10, 15, 20, 30, 50 clay. Dry pressed briquettes were made using 50 to 60% water, and were burned at cones 06, 02 and 2. Heat conductivity tests were made upon the best bodies of the series.

Introduction

The purpose of this thesis is the development of a method of producing an insulating brick from crushed or powdered diatomaceous earth.

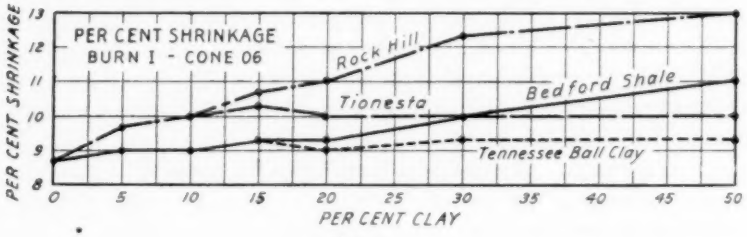

Fig. 1.

A great amount of crushed material is produced in mining this material and at present there is an excess of this crushed material over that needed in the industries.

Diatomaceous earth is also called infusorial earth, bergmehl, tripoli, moler, fossil earth, white peat, celite, kieselguhr, and sometimes erroneously

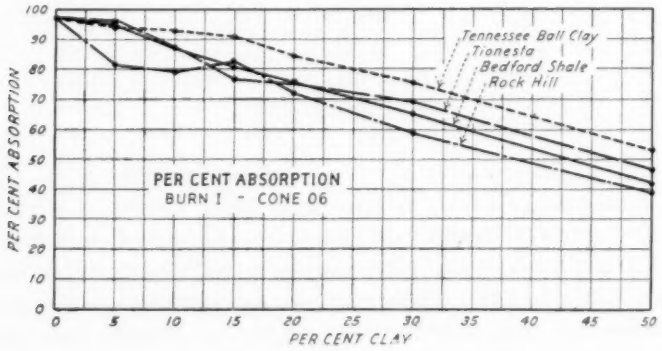

Fig. 2.

referred to as "desmid earth," and is widely distributed in deposits in the United States and Europe in varying degrees of purity. Strictly speaking, it is composed of the microscopic skeletons of bacillariae or diatoms,

one of the groups of flowerless salt and fresh-water plants of the species "algae."

The chief impurities are diatomaceous silt, clay, sand or volcanic ash, and other inorganic materials. The chief deposit in the United States is near Lompoc, Santa Barbara County, Calif. This is of exceptional purity. The material occurs in beds of minimum thickness of seven hundred feet, ranging from soft material to hard black flint, and as mined, contains from 25 to 40% H_2O, which can be expelled at 100°C.

COMPOSITION OF MATERIAL IN LOMPOC DEPOSIT[1]

	1	2	3		1	2	3
SiO_2	88.78	85.28	94.59	MgO	1.3	1.30	trace
Al_2O_3	2.68	5.35	1.87	Ignition loss	5.54	5.57	2.22
FeO	trace	1.12	0.76	Color	white	ivory	white
TiO_2	0.10	0.21	0.10	Color after ignition	white	pink	white
CaO	1.61	1.12	0.83				

1. Very light, pure white diatomaceous earth.
2. Light weight, brownish diatomaceous earth.
3. Compact diatomaceous shale.

The true specific gravity of this earth is from 2.1 to 2.2 at 25°C, and in block form, as quarried, the apparent specific gravity is about 0.45 or approximately twenty-eight pounds per cubic foot. When loosely packed, the apparent specific gravity is approximately 0.13, or eight pounds per cubic foot.

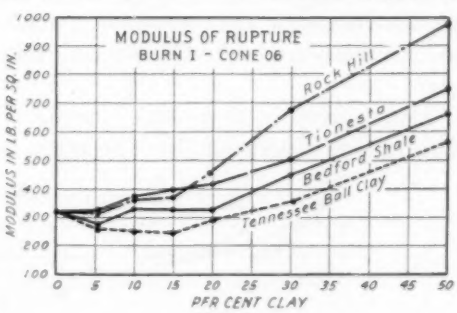

FIG. 3.

Outline of Procedure

The following method of procedure was adopted:

1. Mixtures of diatomaceous earth and clay in proportions of 5, 10, 15, 20, 30 and 50% of clay by weight were made up with four types of plastic clay. The clays were ground to pass an 80-mesh sieve.

The diatomaceous earth was the standard commercially air-separated material, sold in bags, and used as heat insulating material.

2. The dry materials were thoroughly mixed by hand, moistened with water and again mixed thoroughly by hand. Sixty per cent of water was added to the 0–5–10–15% clay mixtures, and 50% to the 20–30–50% clay mixtures. This amount of water made the material suitable for dry pressing.

[1] *Met. and Chem. Eng.*, **12**, 109 (1914).

3. Briquettes, 1 x 1 x 4 inches, were made in a press. Shrinkage marks were impressed and the briquettes then dried for forty-eight hours at approximately 75°C (170°F). The drying shrinkage in all cases was negligible.

4. Four trials of each body were fired at cones 06, 02 and 2. The

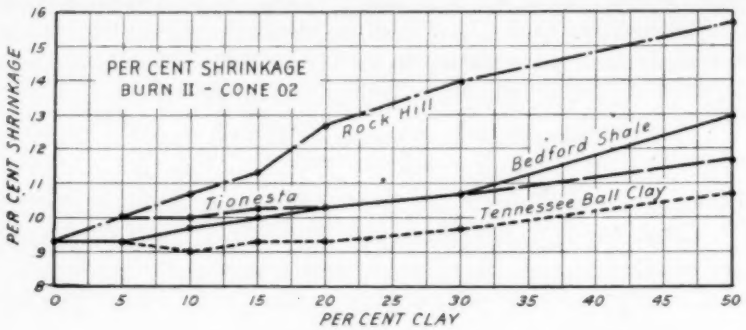

FIG. 4.

cone 06 and cone 02 burns were made in a gas-fired muffle kiln, the briquettes being hacked very openly five high. The cone 2 burn was made in a direct gas-fired kiln in open saggers, being widely spaced in the saggers.

5. The trials were tested for shrinkage, absorption, and modulus of rupture. In breaking the briquettes, a Riehlé load testing machine was used for bars breaking at seventy-five pounds and over, while bars breaking at lower loads were broken by pouring lead shot into a bucket at a constant rate.

Due to limit in time, heat transfer tests were made only on those tile having high absorption, low shrinkage and fair modulus of rupture. The

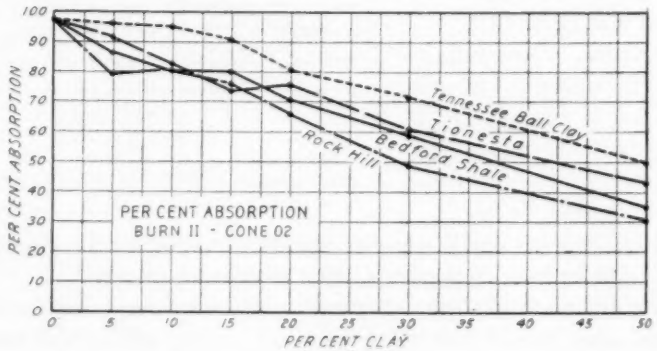

FIG. 5.

figures given represent the ratio of the heat transferring ability of the sample tested to that of a standard material having an index of 1.0. This standard is Alundum. According to this classification, ordinary sawed

diatomaceous earth block has an index of 0.263. "Carbofrax B" (92% Si C) has an index of 3.39, and magnesite an index of 2.33. Thus the smaller the index, the greater the insulating ability of the material, and vice versa.[1]

TABLE I

RESULTS OF BURN I—CONE 06

Fired to cone 06 down in 24 hours, cooled 12 hours and ware removed.

Briquette Serial No.	Average per cent total shrinkage	Average per cent absorption	Average modulus, lbs. per sq. in.
100% Diatomaceous earth	8.7	97.2	320.0
[1]B-5	9.0	94.8	263.0
B-10	9.0	86.8	330.5
B-15	9.3	81.0	326.0
B-20	9.3	75.4	326.5
B-30	10.0	64.7	448.5
B-50	11.0	41.7	659.5
[2]T-5	9.7	96.4	324.0
T-10	10.0	87.1	371.5
T-15	10.3	76.4	397.5
T-20	10.0	74.8	417.0
T-30	10.0	68.8	502.0
T-50	10.0	46.1	745.5
[3]TB-5	9.0	94.4	259.0
TB-10	9.0	92.8	249.0
TB-15	9.3	90.7	243.0
TB-20	9.0	84.4	288.0
TB-30	9.3	75.2	353.0
TB-50	9.3	53.0	559.0
[4]R.H.-5	9.7	81.4	313.0
R.H.-10	10.0	79.0	362.5
R.H.-15	10.7	82.3	370.0
R.H.-20	11.0	71.8	456.0
R.H.-30	12.3	58.4	674.5
R.H.-50	13.0	38.4	979.0

[1] B—Bedford shale.
[2] T—Tionesta.
[3] TB—Tennessee ball.
[4] R.H.—Rock Hill.

Observations in Molding Briquettes

The soft or stiff mud process of making brick could not be used successfully with a diatomaceous earth low in clay. First of all, the material has not enough plasticity to enable it to hold together in being forced through a die, and, second, the material will absorb such large quantities

[1] A. S. Watts and R. M. King, "The Method of Measuring Heat Transfer Values," *Jour. Amer. Ceram. Soc.*, **6** [10], 1075 (1923).

of water before it becomes wet, that it would be impractical to mix it to the necessary consistency in a pug mill, due to the very strong tendency to form balls of damp material having an outer coating of dry diatomaceous earth. While diatomaceous earth can be molded by dry pressing without any clay bond and with 60% water, the briquette is very weak and will stand very little handling. Clays in percentages of 5–10–15 do not affect the strength greatly but percentages of 20–30–50 have a very decided effect on the molding properties. The 20 to 50% clay briquettes could be handled by careful workmen.

Since it was found that clay, in amount of 20% and over, was satis-

TABLE II

RESULTS OF BURN II—CONE 02

Fired to cone 02 down in 28 hours, cooled 12 hours and ware removed.

Briquette serial no.	Average per cent total shrinkage	Average per cent absorption	Average modulus, lbs. per sq. in.
100% Diatomaceous earth	9.3	97.0	377.0
B-5	9.3	86.4	379.0
B-10	9.7	80.2	415.5
B-15	10.0	80.2	420.0
B-20	10.3	70.5	379.7
B-30	10.7	58.7	580.5
B-50	13.0	34.6	1077.0
T-5	10.0	91.3	430.5
T-10	10.0	82.6	563.0
T-15	10.3	73.7	543.0
T-20	10.3	75.7	518.3
T-30	10.7	60.8	748.0
T-50	11.7	43.1	1082.0
TB-5	9.3	96.5	208.0
TB-10	9.0	94.7	258.5
TB-15	9.3	90.6	294.0
TB-20	9.3	80.5	350.5
TB-30	9.7	71.3	442.0
TB-50	10.7	49.4	609.3
R.H.-5	10.0	79.1	404.0
R.H.-10	10.7	80.6	400.0
R.H.-15	11.3	75.3	494.5
R.H.-20	12.7	66.1	704.5
R.H.-30	14.0	48.6	980.0
R.H.-50	15.7	30.2	1270.0

		Per cent shrinkage	Per cent absorption	Modulus, lbs. per sq. in.	Heat transfer value
First choice	20% Tenn. ball.	9.3	80.5	350.5	0.321
Second choice	20% Tionesta...	10.3	75.7	518.3	0.292
	100% Diat. earth..	9.3	97.0	377.0	0.274

factory in the raw state, no amount less than that will be considered in the choice of a mixture.

		Per cent shrinkage	Per cent absorption	Modulus, lbs. per sq. in.	Heat transfer value
First choice	20% Tenn. ball.....	9.0	84.4	288	0.252
Second choice	25% Tenn. ball.....	9.2	80.0	320	0.280
Third choice	20% Bedford shale.....	9.3	75.4	326.5	...
	100% Diat. earth.....	8.7	97.2	320	0.274

The Rock Hill clay shows a very marked degree of vitrification, producing a dense brick unsuited for good insulating.

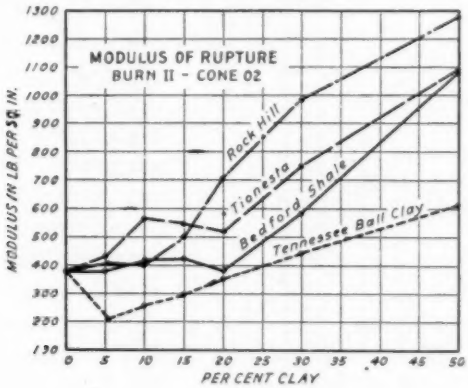

FIG. 6

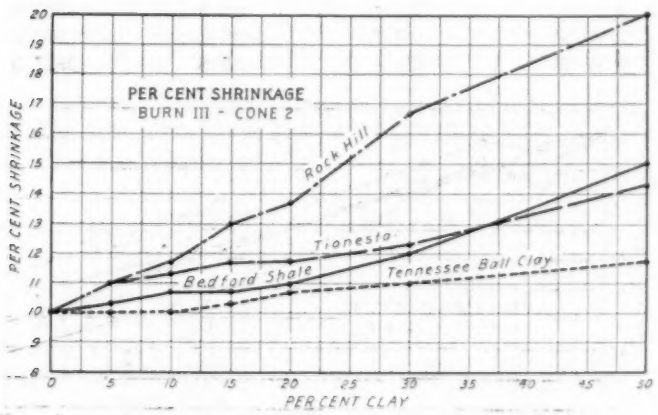

FIG. 7.

Bedford shale and Tionesta are starting to tighten up in clay percentages of 20 to 50%, and Tennessee ball clay mixtures of 30 to 50% are becoming too dense for a high grade insulating material.

All the clay bodies increased in density to such an extent that the insu-

TABLE III

RESULTS OF BURN III—CONE 2

Fired to cone 2 down in 24 hours, cooled 18 hours and ware removed.

Briquette serial no.	Average per cent total shrinkage	Average per cent absorption	Average modulus, lbs. per sq. in.
100% Diatomaceous earth	10.0	92.0	535.0
B-5	10.3	88.8	479.5
B-10	10.7	78.5	582.0
B-15	10.7	76.7	625.0
B-20	11.0	68.1	552.7
B-30	12.0	54.8	827.0
B-50	15.0	28.7	1552.0
T-5	11.0	81.5	717.0
T-10	11.3	80.2	725.0
T-15	11.7	72.3	815.0
T-20	11.7	69.0	773.0
T-30	12.3	55.9	1068.0
T-50	14.3	36.8	1571.0
TB-5	10.0	86.1	402.0
TB-10	10.0	89.0	380.0
TB-15	10.3	81.6	494.0
TB-20	10.7	74.6	607.5
TB-30	11.0	64.9	589.5
TB-50	11.7	43.6	722.0
R.H -5	11.0	73.9	630.0
R.H.-10	11.7	82.7	562.5
R.H.-15	13.0	73.1	763.0
R.H.-20	13.7	59.9	1013.5
R.H.-30	16.7	41.4	1504.0
R H.-50	20.0	17.8	2827.0

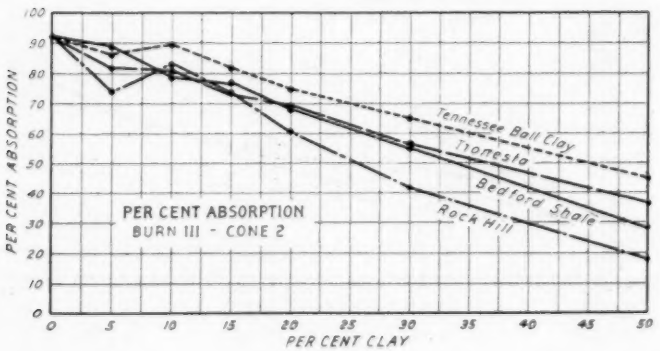

FIG. 8.

lation value was much inferior to pure diatomaceous earth and to that of the ware of the previous burns, but it was still sufficient for them to be classed as good insulators. The best bodies were as follows:

		Per cent shrinkage	Per cent absorption	Modulus, lbs. per sq. in.	Heat transfer value
First choice	20% Tenn. ball...	10.7	74.6	607.5	0.364
Second choice	20% Bedford shale	11.0	68.1	552.7	...
	100% Diat. earth...	10.0	92.0	535.0	0.351

Summary of Results of All Burns

A body composed of 80% of diatomaceous earth and 20% of Tennessee ball clay is satisfactory for dry pressing into brick, using 50% water. The clay and the diatomaceous earth should be mixed thoroughly dry before any water is added, and after adding water, the materials must be again thoroughly mixed. In factory practice, the dry mixing could be done in tube mills containing *Z* bar projections, and the water could be added as is done in dry press porcelain insulator manufacture, after which the body should be put through a high speed disintegrator to more uniformly distribute the moisture and to pulverize the material.

This body, when burned at cone 06, produces high absorption, low increase in shrinkage, and a modulus of rupture sufficiently high for the purpose of insulation.

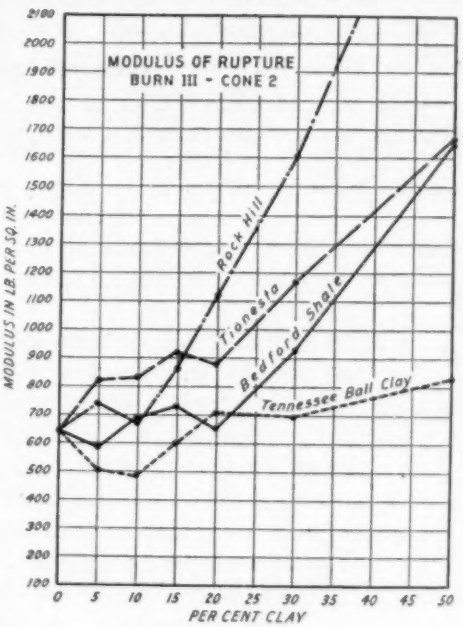

FIG. 9.

The properties of the first and second choice bodies are:

		Per cent shrinkage	Per cent absorption	Modulus, lbs. per sq. in.	Heat transfer value
First choice	Tenn. ball 20%.... Cone 06	9.0	84.4	288	0.252
Second choice	Tenn. ball 20%.... Cone 02	9.3	80.5	350.5	0.321
	Tenn. ball 25%.... Cone 06	9.2	80.0	320	0.280

The resistance to abrasion of the two second choice bodies is of equal quality, and is slightly greater than first choice, so if this property is more desirable than absorption (as in very long shipping), greater resistance to

abrasion may be obtained by either an increased fuel cost or an increased cost of material, *i. e.*, clay.

The above results prove conclusively that a commercially satisfactory insulating brick can be made from pulverized diatomaceous earth and clay by the dry press process, if care is taken in pulverizing the materials, in thoroughly mixing of materials, both when dry and wet, and in handling of ware in the unburned state. These brick, while not equal in insulating value to the quarry sawed diatomaceous earth block, are so much superior in other physical properties that they should be able to supply an extensive market.

Acknowledgment

NOTE: The author wishes to hereby express his appreciation and acknowledgment of the many helpful suggestions of A. S. Watts, under whom this thesis was conducted.

THE DEAD BURNING OF DOLOMITE.—I[1]

By James Thomas Robson and James R. Withrow[2]

This is the first of a series of articles covering the second phase of an investigation by the U. S. Bureau of Mines, in coöperation with the Ohio State University, into the possibility of utilizing dolomite as a base material in the manufacture of refractories.

Introduction

Dolomite, a double carbonate of lime and magnesia having the theoretical formula $CaCO_3MgCO_3$, when formed and burned into bricks possesses the undesirable property of disintegrating when standing in the air, due to the slaking of the lime content. Since dolomite is very abundant and possesses great refractoriness together with basic properties similar to magnesite, it is very desirable that this serious slaking defect be overcome so that it may act as a substitute for the more expensive magnesite.

This work was carried on (1) to obtain dolomite in the dead burned form, and (2) to investigate the feasibility of producing standard size bricks of dead-burned dolomite composition.

The term "dead burned" dolomite signifies dolomite which is in the stable form after burning and will not slake down upon prolonged exposure to the atmosphere.

The total apparent consumption of crude magnesite in the United States for 1921, amounted to 113,479 short tons of which 58% was imported.

Normal consumption of magnesite in the United States, in terms of crude, amounts to about 300,000 tons of which a large part is dead burned and consumed by the steel and other metal industries. The year 1921, therefore, resulted in an apparent consumption of but little more than a third of this amount. This was due to the slump in the metal industries.

The entire domestic production of 47,904 tons came from California. That state produces but little dead-burned material, most of the ore being sold as caustic magnesite for other than metallurgical work.

The estimated value per ton of domestic crude ore was $10.65 as against $10.01 for the imported material. The total value of imported magnesite was $525,452 and that of the domestic production $510,177. Of total imports but 6,788 tons were calcined, the remainder 51,993 tons having been brought in as crude. This was probably due to fuel and labor conditions at the point of shipment.[3]

On February 6, 1923, crude magnesite was quoted at $14.00 per ton and calcined magnesite $40.00 per ton f. o. b. California points. The dead-

[1] Published by permission of the Director, U. S. Bureau of Mines.

The first phase of the work has been in three previous arcticles by H. G. Schurecht as cited.

The authors are indebted to G. A. Bole, A. S. Watts and W. J. McCaughey for valuable suggestions.

burned magnesite grains were quoted at $40.00 per net ton f. o. b. at Baltimore and at $40.50 and $42.00 at Chester, Pa. Magnesite bricks, nine-inch straights were quoted at $65.00 and $68.00 per ton f. o. b. the works. At the same time, dolomite one-half inch and larger was quoted at $1.10 and $1.35 per net ton at New York state shipping points.

Magnesite refractories are used in basic open hearth steel furnaces where a number of courses of magnesia brick are used in making the foundation for the bottom, the bottom being made of dead-burned magnesite, and in many cases at present, of granular dolomite. Side walls are built of magnesia brick to a height of about 15 inches above the bottom of the charging doors. They are used around the door jambs and tapping holes, and to face the furnace blocks as a protection to the silica bricks.

Magnesia bricks are used in the construction of soaking pits in the six or eight bottom courses; along the slag line of metal mixers; in the bottom and on the bridge wall of billet and bar heating furnaces; in the bottom side walls and bridge walls of copper reverberatories; in copper converters and special types of furnaces such as silver slimes, dross and bullion furnaces, electrical smelting, heating, welding and melting furnaces, calcium carbide kilns and other furnaces.

Previous Work

Many attempts have been made to obtain a dead burned dolomite but with varied success. There have been three general lines of procedure employed in these attempts which are as follows:

1. By mixing an impurity with finely ground dolomite and calcining the mixture.[1] The impurities used are: silica, iron oxide, roll scale, flue dust, alumina, chromium oxide, manganese oxide, cobalt oxide, nickel oxide, borax, blast furnace slag, basic open hearth slag, shale, kaolin, coal tar, calcium chloride, magnesium chloride and sodium chloride.

2. By mixing an impurity with coarsely ground dolomite (2–8 mesh) and calcining the mixture.[2] An example of this method is that used in recent times for making sinter dolomite by allowing the grains of dolomite to float about in a bath of molten iron, until the entire grain has encased

[1] G. L. Davison, "Dead Burning Magnesite," U. S. 792,382 June 20 (1905); C. B. Stowe, "Dead Burning Magnesite," U. S. 205,056, Nov. 14 (1916); G. O. Handy and R. M. Isham, "Dead Burning Dolomite," U. S. 1,270,818, July 2 (1918); S. B. Newberry, "Dead Burning Dolomite," U. S. 1,267,686, May 28 (1918); H. G. Schurecht, "Experiments in Dead Burning Dolomite," *J. Am. Ceram. Soc.*, **2** [4], 291 (1919); A. Rollason, "Refractory Substances," Brit. 156,447, April 21 (1920); H. G. Schurecht, "Experiments in Dead Burning Dolomite and Magnesite," *J. Am. Ceram. Soc.*, **4** [2], 127 (1921); C. H. Breeswood, "Dolomite Bricks," U. S. 1,380,701, June 7 (1921).

[2] F. A. Jones, "Process of Producing a Furnace Lining with Dolomite," U. S. 151,535, Jan. 1 (1918); M. Backheuer, "The Preparation of the Dolomite-tar Mixture in Thomas (basic converter) S eel Works," *Stahl u. Eisen*, **41**, 954 (1921).

itself in a protective coating of iron. Also the present used methods for sintering coarse dolomite with basic open hearth slag or other flux come under this classification.

3. The third method used is to separate the MgO from dolomite ($MgCa(CO_3)_2$). It is much easier to dead burn MgO than CaO since CaO has a greater tendency to combine with water and slake, hence several methods have been proposed to extract the MgO from dolomite and use it as a refractory.[1]

This separation of MgO from CaO after calcining the dolomite at various temperatures is accomplished in several ways, such as by chemical-treatment, flotation, elutriation, leaching and screening.

There are also methods used where the dolomite is not previously calcined.[2]

The most promising and generally used methods for attempting to dead burn dolomite for brick purposes are those methods listed in section 1 where the finely ground dolomite is calcined together with a flux.

For dead burning dolomite in granular form, method 2 is in general use.

This grain dolomite is used for bottoms of basic open hearth furnaces and patching. Magnesite bricks are used for the foundation of the bottom and granular dolomite or magnesite for the remainder. When the dolomite is burned at the plant it may be mixed with slag and sintered into place in the same way as magnesite. When prepared dolomites are used, this latter step is sometimes unnecessary as they have the proper composition for setting. Analysis of some of these prepared dolomites are as follows:[3]

	SiO_2	Fe_2O_3-Al_2O_3	CaO	MgO	Mn	Ignition loss
Magdolite.....	5.77	6.12	51.05	35.05	n. d.[1]	0.82
Magnite.....	1.35	1.52	59.70	37.77	n. d.	.50
Madgebrent.....	1.84	8.17	56.86	31.26	0.20	.51
Dolite.....	2.20	0.86	57.37	38.16	n. d.	.85
Syndolag.....	4.66	6.18	52.80	31.76	0.98	.51

[1] No determination.

The construction of a furnace bottom requires about 90 tons of grains and 25 tons of ground slag.

When a furnace is operated intermittently, especially with prolonged shut-downs, the use of dolomite in any great thickness is unwise because it will slake to a powder upon exposure to the atmosphere. Even treated dolomites slake rather easily.

[1] R. Scherer, "Der Magnesit," *A. Hartleben's Verlag, Wien u. Leipsig*, **84**, 134, 135 (1908); J. A. Bradburn, "Process of Obtaining Magnesia," U. S. 1,156,662, Oct. 2 (1915); A. M. Mitchell, "Process for Obtaining Magnesium Oxide from Dolomites," U. S. 1,273,110, July 16 (1918)

[2] H. Scherer, *ibid.*, p. 134.

[3] H. E. Townsend, Report, *Elec. Fur. Assn.*, **79**, Oct. 6 (1920).

Schurecht[1] made a careful study of the effects of fine grinding and different calcination temperatures on dolomite using the following fluxes: flue dust, iron ore, basic open hearth slag, kaolin and roll scale. The dolomite was ground to 100-mesh and 40-mesh and calcined with the above fluxes at cones 14, 20 and 26, in a Hoskins carbon resistance furnace. The tendency to slake is measured by the tendency the body shows to increase in weight.

The results he obtained may be summarized as follows:

1. Flue Dust and Dolomite.—Grinding the dolomite to 100-mesh size before calcination decreased its tendency to slake over that of 8-mesh dolomite. Also, increasing the calcination temperature above cone 14 increased the tendency of the dolomite to slake. Increase of flux in 40-mesh dolomite decreased the tendency to slake up to an addition of 10%. Above 10% flux, the tendency to slake varied with different percentages of flux.

2. Iron Ore and Dolomite.—Fine grinding of the raw dolomite decreases the tendency to slake. Increasing the calcination temperature above cone 14 again increases the tendency of the dolomite to take up moisture and carbon dioxide. The increase in flux acts similar to flue dust as given in the foregoing paragraph.

3. Basic Open Hearth Slag and Dolomite.—A mixture of 8-mesh dolomite and basic open hearth slag increased in weight much more than a similar mixture with 100-mesh dolomite. Increasing the calcination temperature above cone 14 likewise increases the tendency of the body to increase in weight even to a greater extent than when flue dust and iron ore were used as fluxes. This is attributed to the fact that the lime and silica content of the slag forms unstable compounds with the CaO of the dolomite.

4. Kaolin and Dolomite.—As before, fine grinding of the raw dolomite increases the resistance to slaking. Also, an increase in calcination temperature above cone 14 increases the tendency of the calcine to increase in weight. This was more pronounced on the high fired specimens than with the corresponding iron ore and flue dust mixtures. Some of the mixtures made with 5 and 10% kaolin were still sound at the end of $2^1/_2$ years storage at room temperature. This is attributed to the comparatively high silica-alumina content which evidently forms hydraulic compounds with the lime, similar to those in Portland cement. Kaolin proved to be a very effective flux in dead burning dolomite, being much better than high iron fluxes, probably due to the fact that alumina and silica are better fluxes of CaO than iron oxide and hence leave less uncombined lime.

[1] H. G. Schurecht, *op. cit.*, **4** [2], 127 (1921).

5. Roll Scale and Dolomite.—A mixture of 8-mesh dolomite and roll scale when calcined, increased in weight more than a mixture of 100-mesh dolomite and roll scale, as in the other cases cited. However, increasing the calcination temperature did not materially cause the product to increase in weight.

6. Chlorides and Dolomite.—Adding calcium chloride, magnesium chloride and sodium chloride individually to dolomite and calcining, decreased the tendency of the calcine to slake to only a very slight extent.

From the above combinations, the following conclusions are drawn:

(1) Grinding the raw material fine, *i. e.*, through a 100-mesh sieve, seems necessary to produce the best results.

(2) In most cases increasing the calcination temperature above cone 14 increases the tendency of the calcined dolomite mixtures to take up moisture and carbon dioxide and to disintegrate, due to the formation of free lime and hydraulic compounds which hydrate slowly in the open air.

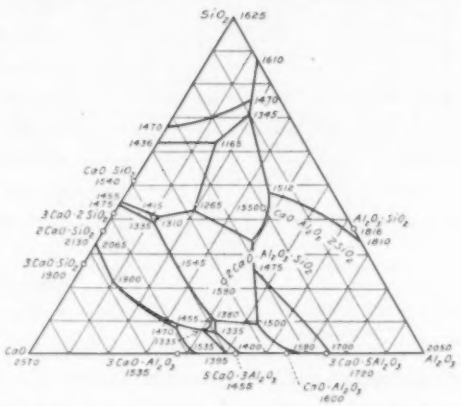

FIG. 1.—Ternary system CaO–Al_2O_3–SiO_2.

(3) Kaolin proved to be the most effective flux used for dead-burning dolomite.

Pyrochemical Behavior of Impurities Found in Dolomite

A review of the work carried on by the Geophysical Laboratory of Washington gives an idea of the pyrochemical behavior of the chief impurities found in dolomites.

The CaO–Al_2O_3–SiO_2 diagram as reported by G. A. Rankin,[1] is shown in Fig. 1. Here we have the compounds, $CaOSiO_2$, $3CaO2SiO_2$, $2CaOSiO_2$, $3CaOSiO_2$, $3CaOAl_2O_3$, $5CaO3Al_2O_3$, $CaOAl_2O_3$, $3CaO5Al_2O_3$ and Al_2O_3-SiO_2. These compounds are at a maximum temperature with eutectics at the points shown. The boundary curves limiting the fields for the stable existence of the compounds (monovariant systems) are also shown. The figures on the diagram denote the fusion points of these mixtures and compounds. Among the natural minerals are found the ternary compounds: anorthite, meionite, gehlenite and grossularite, all lime-silica-alumina minerals. Grossularite and meionite do not form by directly fusing together the pure oxides, but nevertheless exist in the natural

[1] G. A. Rankin, *Am. J. Sci.*, **39**, 25 (1915).

minerals. By fusing together the three oxides CaO, Al_2O_3 and SiO_2, we may thus obtain, at least, two ternary compounds: anorthite ($CaOAl_2O_3$-$2SiO_2$) and gehlenite ($2CaOAl_2O_3SiO_2$) and the eight binary compounds shown on the diagram.

These compounds are all stable and hence if the free lime ordinarily formed when calcining dolomite can be put into combination as any of these forms, there will be little danger of the hydration of free lime. The chief undesirable constituent to avoid is the β orthosilicate which inverts into the stable fine powder γ orthosilicate as will be mentioned later. The β dicalcium silicate has an index of refraction equal to 1.645 ± 0.003, the index of γ dicalcium silicate is 1.654 ± 0.003. The birefringence is medium, about 0.015.

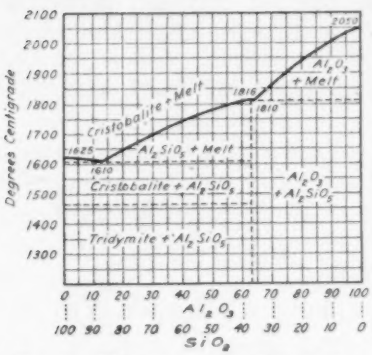

FIG. 2.—Binary system Al_2O_3–SiO_2. Weight, per cent.

The effect of alumina on silica is shown in Fig. 2. There is only one compound sillimanite, $Al_2O_3SiO_2$, which forms eutectics on either side of it. The eutectic between sillimanite and corundum occurs at 64% Al_2O_3 and 36% SiO_2 at a temperature slightly below the melting point of pure sillimanite, 1816°C. The eutectic between sillimanite and cristobalite occurs at 1610°C.

The Ternary System MgO–Al_2O_3–SiO_2[1]

This system is shown in Fig. 3. Here we see that the binary compounds $2MgOSiO_2$ (forsterite), $MgOSiO_2$ (enstatite), $MgOAl_2O_3$ (spinel), $Al_2O_3SiO_2$ (sillimanite), and a ternary compound $2MgO2Al_2O_35SiO_2$ (cordierite) may form, which all have lower melting points than MgO itself besides various eutectics as shown in the triaxial.

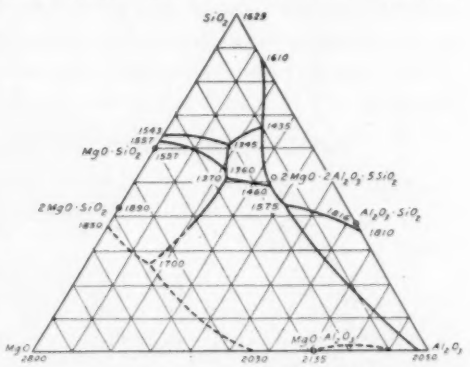

FIG. 3.—Ternary system MgO–Al_2O_3–SiO_2

The Ternary System CaO–MgO–SiO_2[2]

For this system see Fig. 4. Here the definite compounds α $CaOSiO_2$ (pseudowollastonite), $3CaO2SiO_2$, α and β $2CaOSiO_2$, $MgOSiO_2$ (clinoen-

[1] Rankin & Merwin, *Am. J. Sci.*, **45**, 304 (1918).

[2] Ferguson & Merwin, *ibid.*, **48**, 109 (1919).

statite), $2MgOSiO_2$ (forsterite), $CaOMgO2SiO_2$ (diopside), $5CaO2MgO-6SiO_2$ and $2CaOMgO2SiO_2$ (akermanite) have fusion temperatures as shown on the diagram.

The System Anorthite–Forsterite–Silica[1]

This system is shown in Fig. 5. The general character of the true ternary part of the diagram is that of a system with no ternary compound and one binary compound, clinoenstatite $MgOSiO_2$ unstable at its melting point of 1557°C. There are two quintuple points. M is an alteration point between anorthite, forsterite and enstatite with a composition of SiO_2 54.20%, Al_2O_3 20.16%, MgO 14.59%, CaO 11.05% and with a melting point of 1260° ± 2°C. The ternary eutectic between anorthite and clinoenstatite and tridymite has a composition of SiO_2 61.90%, Al_2O_3 18.51%, CaO 10.15%, MgO 9.44% having a temperature of 1222° ± 2°C.

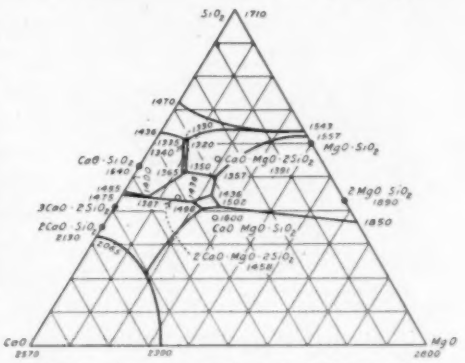

FIG. 4.—Ternary system CaO–MgO–SiO_2.

The Ternary System CaO–Al_2O_3–MgO.[2]

This system is shown in Fig. 6. As shown there is no ternary compound formed. There are six quintuple points of the following compositions and melting points:

Point				Melting point
1	CaO 51.5	Al_2O_3 42.3	MgO 6.2	1450° ± 5°
2	CaO 46.0	Al_2O_3 47.7	MgO 6.3	1345° ± 5°
3	CaO 41.5	Al_2O_3 51.8	MgO 6.7	1345° ± 5°
4	CaO 40.7	Al_2O_3 52.4	MgO 6.9	1370° ± 5°
5	CaO 33.3	Al_2O_3 63.2	MgO 3.5	1550° ± 5°
6	CaO 21.0	Al_2O_3 74.0	MgO 5.0	1680° ± 20°

Preliminary Report on the System Lime–Ferric Oxide[3]

Figure 7 shows the binary system lime–ferric oxide. There are only two calcium ferrites having the formula of the dicalcic ferrite ($2CaOFe_2O_3$) and the monocalcic ferrite ($CaOFe_2O_3$) with dissociation temperatures at 1436° and 1216°C, respectively.

[1] Olaf Anderson, *Am. J. Sci.*, **39**, 440 (1915).
[2] Rankin & Merwin, *J. Am. Chem. Soc.*, **38**, 575 (1916).
[3] Sosman and Merwin, *J. Wash. Acad. Sci.*, **6**, 532–7 (1916).

Campbell[1] shows that if a mixture of pure silica, ferric oxide and calcium oxide of the same molecular proportion as those found in the celite drawn off from Portland cement clinker, is melted and slowly cooled, large crystals of tricalcic silicate will separate, thus demonstrating that calcium ferrite may act as a solvent for both calcium silicate and lime, in a manner almost exactly similar to that of the calcium aluminate.[2]

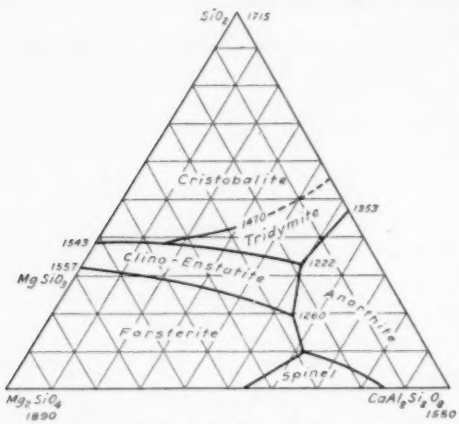

FIG. 5.—System anorthite–forsterite–silica.

CaO–MgO System[3]

Figure 8 shows the effect of lowering the melting point of MgO by the presence of CaO. In this system it was found that in all fused mixtures of CaO and MgO, the two oxides crystallize out side by side, showing no evidence of combination, that is, there is no stable compound formed. The eutectic formed has the approximate composition CaO 67%, MgO 33% and its melting point is $2300° \pm 50°$ which, as seen from the other curves shown, is a higher fusion point than where Al_2O_3, Fe_2O_3 or SiO_2 are added to CaO or MgO.

The effect of Al_2O_3 and SiO_2 on lowering the fusion temperature of CaO, MgO and CaO MgO (the theoretical ratio in which CaO and MgO exist in dolomite), as obtained from the previous curves is shown in Figs. 9 and 10. These curves show that SiO_2 has a much greater effect on lowering the fusion temperature of MgO than Al_2O_3 has. SiO_2 lowers the fusion temperature of CaO

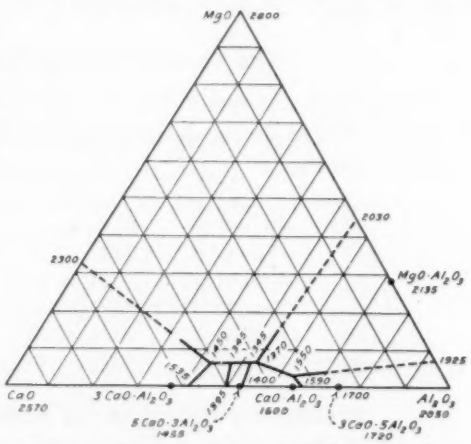

FIG. 6.—Ternary system CaO–Al_2O_3–MgO.

[1] Campbell, "Function of Ferric Oxide in the Formation of Portland Cement Clinker," *J. Ind. Eng. Chem.*, **7**, 835–7 (1915).

[2] H. A. Miers, *Mineralogy*, p. 385 (1902) states that iron oxide forms a spinel with Al_2O_3 of the formula $FeOAl_2O_3$ called hercynite.

[3] Rankin and Merwin, *J. Am. Chem. Soc.*, **38**, 571 (1916)

MgO more rapidly and to a lower temperature than does Al_2O_3. On the contrary Al_2O_3 lowers the fusion temperature of CaO more rapidly and to a greater extent than does SiO_2. The fusion temperature of CaO MgO with SiO_2 as a flux is lower than that of CaO or MgO alone with SiO_2 as a flux. In greater amounts than about 21% and less than about 83%, Al_2O_3 lowers the fusion temperature of pure CaO below that of CaO MgO.

Schurecht[1] found that a large percentage of iron oxide 20–30% with 80–70% dolomite may be used without decreasing the refractoriness below cone 31. Impurities which are siliceous in character like kaolin, he found to decrease the refractoriness to a much greater extent. Work later on in this article will show that it was probably not the presence of silica which caused the decrease in refractoriness, but the presence of Al_2O_3 which caused the excessive lowering in the fusion temperature.

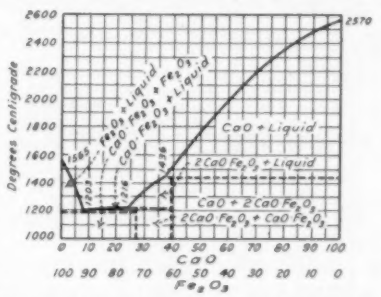

FIG. 7.—The binary system $CaO–Fe_2O_3$.

From these aforementioned diagrams and data we see that any of the following compounds may exist in dead-burned dolomite when Fe_2O_3, Al_2O_3 and SiO_2 are present:

$CaO\ SiO_2$—Wollastonite	$3CaO\ 5Al_2O_3$
$3CaO\ 2SiO_2$	$CaO\ Al_2O_3\ 2SiO_2$—Anorthite
$2CaO\ SiO_2$—Calcium orthosilicate	$2CaO\ Al_2O_3\ SiO_2$—Gehlenite
$3CaO\ SiO_2$—Tricalcium silicate	$MgO\ SiO_2$—Enstatite
$CaO\ MgO\ SiO_2$—Monticellite	$2MgO\ SiO_2$—Forsterite
$CaO\ MgO\ 2SiO_2$—Diopside	$MgO\ Al_2O_3$—Spinel
$2CaO\ MgO\ 2SiO_2$—Akermanite	$2MgO\ 2Al_2O_3\ 5SiO_2$—Cordierite
$5CaO\ 2MgO\ 6SiO_2$	$5CaO\ 2MgO\ 6SiO_2$
$3CaO\ Al_2O_3$—Tricalcium aluminate	$Al_2O_3\ SiO_2$—Sillimanite
$5CaO\ 3Al_2O_3$	$2CaO\ Fe_2O_3$—Dicalcic ferrite
$CaO\ Al_2O_3$—Calcium aluminate	$CaO\ Fe_2O_3$—Monocalcic ferrite

Since, as shown by these diagrams, the compounds and especially the eutectic mixtures have fusion points at relatively low temperatures, in all probability the amount of flux added to the dolomite will have to be limited to within a few per cent of the dolomite so as not to exercise too great an influence on the softening temperature of the mixture, thus destroying its value as a refractory.

Of course these diagrams represent equilibrium conditions, *i. e.*, that the compounds and components as represented would occur together in mixtures if time were allowed for the reaction to go to completion which most

[1] H. G. Schurecht, *J. Am. Ceram. Soc.*, **2** [4], 305 (1919).

probably will not be the actual case when dolomite is calcined with fluxes. The diagrams show, however, what compounds may be formed in calcining such a mixture. They show that there are numerous possibilities in forming various eutectic mixtures and also stable compounds which may be formed by reaction of the fluxing oxides with CaO and MgO of the dolomite, or it is possible that a eutectic mixture or compound may be formed between all the oxides which will dissolve the excess CaO and MgO, thus producing a stable form. Absolutely dead-burned magnesite has the magnesite essentially in the form of periclase.[1] By adding fluxes to dolomite and calcining at a sufficiently high temperature, it may be possible to form the MgO into periclase and have the otherwise free lime, which would tend to slake, combine with the fluxes present to form stable compounds.

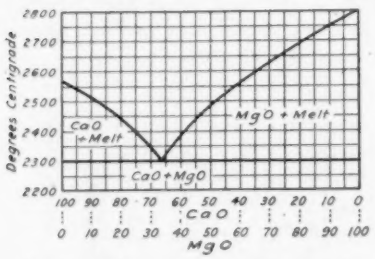

FIG. 8.—Binary system CaO–MgO.

Austrian magnesite, which dead burns to form the ordinary magnesia brick, is called Breunnerite, which is an isomorphous mixture of magnesium and iron carbonates. When this mineral is calcined and dead burned the resulting product takes on a yellowish tinge. This is due to the solution of the ferric oxide formed into the periclase formed. Adding iron oxide to a magnesite too low in the iron oxide content gives a satisfactory product.[2]

The composition of Breunnerite varies from 95–70% $MgCO_3$ and 5–30% $FeCO_3$.[3]

Pike[4] states that amorphous magnesite raised to a temperature of 1550°C in the presence of 5–6% Fe_2O_3 is transformed into periclase which is dense, hard and sintered and known as dead-burned magnesite. Microscopic examination demonstrates that Fe_2O_3 added to the rock under proper conditions is equivalent in action to the iron occurring naturally in the rock. The natural occurring

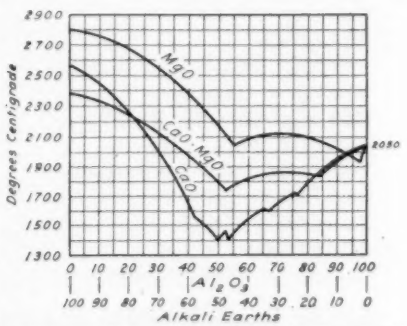

FIG. 9.—Effect of Al_2O_3 on the fusion of CaO, MgO and CaO. MgO.

[1] J. S. McDowell and R. M. Howe, "Magnesite Refractories," *J. Am. Ceram. Soc.*, **3** [3], 211 (1920).

[2] J. S. McDowell and R. M. Howe, *loc. cit.*, **3** [3], 190–1 (1920).

[3] Thos. Crook, "Magnesite as Raw Material," *Trans. Ceram. Soc.* (Eng.), **18,** 75 (1918–19).

[4] R. D. Pike, "Electric Furnace Refractories," *Chem. Met. Eng.*, **23,** 1148 (1920).

crystalline Austrian magnesite or Breunnerite, however, is far superior to other forms of magnesite[1] and is the chief product used for making magnesia brick in the United States today. Since Breunnerite which contains iron carbonate, forms a better dead-burned product than crystalline Washington magnesite which is low in iron, and since a small percentage of iron oxide, 4.5–8.0%, is considered necessary for the production of dead-burned magnesite for refractory purposes,[2] it appears to be advisable to add it as one of the fluxes in dead-burning dolomite, since if a small percentage of ferric oxide is added to a pure dolomite, the two finely ground together and calcined at a high temperature, there is a tendency to approach the homogeneous composition of Breunnerite.

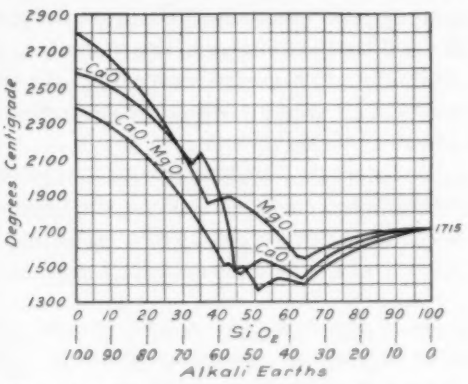

FIG. 10.—Effect of SiO_2 on the fusion of CaO, MgO and CaO . MgO.

The presence of impurities, especially silica and silicates, causes lime to be overburned. This appears to be true since it has been found practically impossible to overburn some very pure limes.[3] Overburned lime is generally yellow or black in color. It is very inactive to water and slakes not at all or very slowly. Thus the presence of silica or silicates when mixed with dolomite may tend to cause the lime to "overburn" when calcined.

Slaking of Dolomite

The disintegration of dolomite is due to the two following causes:

1. Disintegration due to change of state on heating and cooling.
2. Disintegration due to slaking by taking up moisture from the air.

In the first case the disintegration is comparatively rapid occurring during the cooling and is due to the inversion from the β to γ form of orthosilicate which starts at about 675°C[4] and continues even after it is removed from the furnace. This inversion is accompanied by a 10% volume change which causes dusting of the orthosilicate and the dolomite

[1] A. F. Greaves-Walker, "Electric Furnace Refractories," *Elec. Fur. Assn.*, **57**, Oct. 6 (1920).

[2] McDowell and Howe, *loc. cit.*, **3** [3], 203 (1920).

[3] W. E. Emley, U. S. Bur Stand., *Tech. Paper* **16** (1913).

[4] Shepard and Rankin, "Preliminary Report on the Ternary System $CaO–Al_2O_3–SiO_2$," *J. Ind. Eng. Chem.*, **3**, 9 (1911).

containing it. Newberry, Richardson, Boudouard and Le Chatelier[1] all noticed this dusting and Le Chatelier ascribed it properly as being due to polymorphism. Schurecht[2] found that blast furnace slag used as a flux for dolomite caused considerable dusting due to this conversion of β $2CaOSiO_2$ to γ $2CaOSiO_2$. This was caused by the high SiO_2 content of the flux. He noticed this dusting to a less extent when flue dust, kaolin or basic open hearth slag were used and mixtures containing roll scale or iron ore showed the least dusting as would be expected. Bates[3] showed that in Portland cement containing above 4.5% MgO, the rapidity and amount of dusting increases with the magnesia content up to about 9.5% MgO content when the orthosilicate begins to decrease again with addition of MgO.

Disintegration due to taking up moisture from the air is due primarily to the presence of free lime in the calcined material which takes up water and forms calcium hydroxide according to the simple chemical equation

$$CaO + HOH \longrightarrow Ca(OH)_2.$$

This is purely a case of lime slaking where the increased volume of the $Ca(OH)_2$ disrupts the mass causing it to slake down into powder. As a secondary reaction we have

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O.$$

Davis[4] shows that "underburned" cement contains a considerable quantity of free lime. Cements such as this when mixed with water set rapidly. The particles of free lime absorb moisture changing to the hydrate of lime and the expansion which accompanies this change produces ominous cracks in the hardened cement.

This disintegration, due to the taking up of moisture, may also be due to various compounds formed in the calcine which possess hydraulic properties and in taking up water from the air, cause the calcined material to disintegrate. Klein and Phillips[5] found that the following compounds will hydrate: $3CaO\ Al_2O_3$, $5CaO\ 3Al_2O_3$, $CaO\ Al_2O_3$, $3CaO\ SiO_2$ and β 2 $CaO\text{-}SiO_2$. They found that $CaO\ SiO_2$ and γ $2CaO\ SiO_2$ do not possess hydraulic properties. Campbell[6] showed that the two ferrites of calcium, monocalcic ferrite and dicalcic ferrite will hydrate also. Magnesium oxide will

[1] Newberry, *J. Soc. Chem. Ind.*, **16**, 887 (1897); Richardson, *Cement*, **4**, 276 (1903); Boudouard, *Rev. de Metal*, 462 (1905); LeChatelier, *Ann. d. Mines*, 345 (1887).

[2] H. G. Schurecht, *J. Am. Ceram. Soc.*, **2** [4], 304 (1919).

[3] P. H. Bates, "Properties of Portland Cement having a High Magnesia Content," U. S. Bur. Stand., *Tech. Paper* **102**, 40 (1918).

[4] A. C. Davis, *Port. Cement*, **22** (1909).

[5] Klein and Phillips, "The Hydration of Portland Cement," *Trans. Am. Ceram. Soc.*, **16**, 313–41 (1914).

[6] E. D. Campbell, *J. Ind. Eng. Chem.*, **11**, 116–20 (1919).

combine with water with reasonable rapidity, only when it has been burned at some temperature below 1100°C. It may be that these compounds, if present in sintered dolomite, will, during the process of their hydration, cause a volume change and cause the calcined dolomite to disintegrate. Schurecht's work showed that compounds having a tendency to increase in weight when exposed to the air are formed in dolomite calcined with various fluxes. Bates[1] shows that Portland cement high in magnesia produces concrete similar, so far as expansion is concerned, to concrete made from the normal composition. This cement shows usually contraction when stored in air and expansion when stored in water. The expansion and contraction of these compounds, however, is only very slight, in most cases not more than a few hundredths of one per cent. A large part of the magnesium does not hydrate, it acts merely as an inert substance which must be heated by the calcium oxide. Therefore, other things being equal, the less magnesium oxide present in a lime, the more quickly will it slake and the greater will be the amount of heat generated. However, a very porous dolomitic lime may slake more quickly than a dense lime with a much higher content of calcium oxide, due to the fact that the water can penetrate the more porous lime more quickly. Evidently it appears that in order to dead burn dolomite, a dolomite of as high MgO content as possible is desirable and as previously mentioned, a fine grained material is desirable in order to develop a dense product.

Summary

Thus it has been shown that:

1. Kaolin appears to be a fairly effective flux for dead-burning dolomite.
2. There are many different compounds and eutectic mixtures capable of formation among the five components CaO, MgO, Fe_2O_3, Al_2O_3, and SiO_2.
3. CaO may combine with Fe_2O_3 and act as a solvent for lime as does also calcium aluminate.
4. The presence of Fe_2O_3 is essential to dead burn MgO to the stable form periclase.
5. Lime is rendered inactive to water by calcination in the presence of impurities especially silica and silicates.
6. The more magnesium oxide present in a lime, the slower will it slake.

In view of these facts it was deemed advisable to carry on this investigation of determining whether or not it is possible to dead burn dolomite using Fe_2O_3, Al_2O_3 and SiO_2 either alone, a combination of any two, or a combination of all three as fluxes.

[1] P. H. Bates, *op. cit.*, 21–4.

CERAMIC ABSTRACTS

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Vol. 3 **January, 1924** **No. 1**

Author Index[1] to Ceramic Abstracts for January

Author	Page
Aktiebolaget Arcus Betongindustri	5
Anon	2, 3, 4, 9, 12, 13, 15, 23, 24, 26, 28
Bacchiolelli, M. and Meifree-Devals, A.	29
Bowen, C. A.	10
Bragg, W., Shearer, G. and Mellow, J. W.	24
Brittain, A. and Elliott, C.	3
Brown, W. F.	10
Campbell, J. C.	10
Chance Bros. & Co., Ltd., and Forster, A. L.	10
Chapman, W. B.	6
Chemische Werke vorm. Auerges	6
Clare, R. L.	23
Cole, L. H.	23
Cook, S. J.	23
Daeves, K.	5
De Keghel, M.	3
Dewey, H.	14
Ferguson, A.	9
Fischer, H.	19
Forse, E. B.	15
Fry, A. T.	4
Garland, C. M.	29
Gary, M.	24
Gelstharp, F.	10
Gevers, J. and Co.	6
Greer, J. B.	11
Groenwall, E. A. A.	21
Hagar, D.	23
Hagiwara, T.	25
Halversen, H. N.	11
Hanrahan, J. F.	20
Hepburn, W. M.	21
Hermant, G.	11
Hind, S. R.	17
Hines, J. H.	13
Hofmann, K. A.	19
Hogenson, W.	6
Holland, J. & Gardner, W. J.	18
Howe, H. E.	29
Hundley, J.	13
Ivanitzka, A. and Orlova, L.	24
Jacobsen, C.	28
J. E. D.	11
Kistyakovskii, V. A.	25, 26
Kontzler, H.	5
Körber, F.	25
Kühl, H.	4
Kullberg, C.	28
Larson, L. J. and Petrenko, S. N.	11
Lillibridge, H. D.	23
Linden, A. G.	5
Luce, G. E.	14
Lustman, A. J.	3
Martin, S. C.	20
Mason, A. G. and Buckley, L. C.	18
Maurach, H.	6
McCutcheon, G. H.	16
McElroy, R. H.	13
Middleton, A. H.	19
Miyaguchi, T.	6
Møller, C. J.	18
Moustier, G.	3
Mueller, A. F.	5
Myers, H. A.	9
Nitzche	4
Odelberg, A. S. W.	17
Parsons, C. E.	2
Peddle, C. J.	6
Pedemonte, A. L.	2
Pike, R. D.	21
Plauson's, Ltd.	26
Ponomarev, I. F.	25
Prévost, P.	26
Prussing, C.	4
Qvidinger, E. S.	5
Rateau, A. C. E.	19
Reid, T. A.	20
Rhoads, T. H.	20
Riddle, F. H.	16
R. M.	3
Roberts, J. T. and Martin, J. C., Jr.	13
Schaefer, R. et cie and Schaefer, H.	16
Schultz, E. H.	15
Seidlenberg, A.	26

[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from the Editor of *Chemical Abstracts* by coöperative agreement.

Author Index to Ceramic Abstracts for January (*Continued*)

Author	Page	Author	Page
Sem, M. O.	20	Vernon, H. M.	17
Short, W. F.	25		
Simon, L.	10	Waite, F. H.	15
Singh, D.	27	Walker, F. W.	22
Strachota, C. A.	15	White, G. N.	16
		Williams, J. A.	22
Thomas	15	Wilson, L. M.	14
Toffelmeyer, C. H.	14	Witte, L. A.	23
Tucker, F. N.	23	Wosnessensky, S.	24

Abrasives

PATENTS

Process of producing carbides of sodium and boron. CHARLES E. PARSONS. U. S. 1,473,510, Nov. 6. The process of simultaneously producing sodium carbide and boron carbide from sodium tetraborate, which consists in melting said borate out of contact with the air; raising the temp. to a point between 1000°C and the point of dissocn. of said borate; adding sufficient carbon to produce the desired sodium and boron carbides; and recovering said carbides.

Alumina. A. L. PEDEMONTE. Brit. 195,295, May 5, 1922. Pure Al_2O_3 is obtained from ferruginous bauxite by heating in a reducing atm. to render the Fe and Ti magnetic, sepg. these impurities by magnetic action, dissolving the purified bauxite in HCl or H_2SO_4, digesting to render SiO_2 and any remaining Ti insol., filtering, and evapg. the filtrate to dryness and calcining the Al salt to obtain Al_2O_3 and recover the acid. (*C. A.*)

Art

Intimate discussion of American china ware. ANON. *Ceramist*, **3**, 38–47(1923).—Foreign porcelain wares are considered as belonging to 2 groups: the porcelain of Limoges (French china) which has a hard feldspar glaze, and English bone china, having a softer glaze. French ware lends itself best to delicate underglaze treatment. Brilliant colors are not often seen and overglaze decorations do not fuse well into the hard glaze. The English china is the supreme ware for rich coloring. Broad bands ground-laid over the glaze and fired hard form a distinctive treatment that is exclusive. All the English overglaze colors are brilliant because the soft glaze assimilates them well. The use of rich gilding is not defended. This method of decoration belongs to the 18th century. It was brought to perfection under the kings of France in probably the most debased period of art in history. The following are cited as examples of epoch making departures in the artistic treatment of ceramic wares: the ivory finish of Royal Worcester wares, 1880–95; Rookwood matt glaze in 1890; Copenhagen overglaze painting, 1893 and Rookwood vellum, 1903. American potters will not undertake the manuf. of hard porcelain, because it will require the adoption of methods radically different from those in present use. The manuf. of English or bone china is the alternative. The following suggestions are made relative to the manuf. of this ware. Cone 10 is better than cone 9 for the biscuit fire. The glaze should not be fired above cone 4; the body will have to be adjusted to the use of feldspar instead of Cornwall stone; the Dillsboro North Carolina kaolin can be used if available of uniform quality. Close attention to the grinding of a body is imperative. The best ware cannot be made on high speed plan. Placing of the bisque and the ware is a special problem which will require careful attention. Decoration of ware should be in charge of a skilful designer who is not bound down by traditions of the past. Seconds ware should not be sold in competition

with the best. Attention is called to the keen interest which is being displayed in the study of pottery and porcelain by women's clubs. C. W. P.

Casein colors and paints. MAURICE DE KEGHEL. *Rev. prod. chim.*, **26**, 469–72, 501–6(1923).—A description of the prepn., properties and uses of water colors having a casein binder, casein paints (for art work), and casein varnishes. A. P.-C. (*C. A.*)

Cement, Lime and Plaster

Artificial cement plants at Marcoing (France). AVRAM J. LUSTMAN. *Rev. Mat. Constr. Trav. Pub.*, **166,** 157–9(1923).—Description with 10 figures of plants of "Société Anonyme des Ciments Artificiels de Cambrésis" started in 1921, with a capacity of 400 tons of artificial cement in 24 hours. L. N.

Slag brick manufacture. ANON. *Rev. Mat. Constr. Trav. Pub.*, **168,** 206–9 (1923). L. N.

Carbonating lime at dull red heat. GERMAIN MOUSTIER. *Rev. Mat. Constr. Trav. Pub.*, **168,** 198–9(1923).—*Hydrated Lime* having the following per cent chem. compn., $SiO_2 + Al_2O_3 + Fe_2O_3$ 1.5, CO_2 0.8, combined H_2O 20.7, total CaO 74.3, MgO 0.6, unanalyzed 2.1, was heated at a dull red heat in a small muffle fur. with a kerosene lamp. After $1^1/_4$ hr. of heating, 150 gm. of lime were found to have been carbonated to the extent of 9.4% of the total CaO. In a series of expts. 0.703 gms. of *quicklime* were heated in a covered platinum crucible to a dull red ht. with an alcohol vapor burner, carbonating of the lime being after 2.3 hrs. of htg. 19.2%, 6.3 hrs. 80.0%, 8.3 hrs. 84%, 10.3 hrs. 85%. The importance of the presence of gases of combustion in the cooling region of kilns is emphasized. L. N.

Resistance of "Vassy" cement mortars to the action of selenitic waters. R. M. *Rev. Mat. Constr. Trav. Pub.*, **168,** 199–202(1923).—A general historic review of French literature relating to the experiments on the natural cement of Vassy, which withstands the destructive action of sea water, and water charged with alk. earth sulphates. (With photographs of testpieces after long exposures.) L. N.

The gypsum industry. A. BRITTAIN AND C. ELLIOTT. *Trans. Ceram. Soc.* (Eng.), **22** [1], 44 (1922–23).—A paper on the consideration of the general methods employed for the conversion of the mineral into its manufd. products and testing of these products. H. F. S.

Fused cement. ANON. *Quarry & Surveyor & Contractors' Jour.*, **28,** 293(1923).—Fused cement tests have revealed that in the Hennibique system a higher coeff. of safety for concrete under the usual stresses is procurable than can be obtained with Port. cement. For concrete beams, the deflections before rupture with fused cement in the mix were always stronger than with Port. cement. Fused cement, however, is not very binding, consequently great care must be observed in pounding, releasing the molds, etc. In the mix, too much sand is better than not enough, and the best propn. of water is 150 l. per 800 l. of gravel and 400 l. of sand; the materials should be mixed till of a plastic consistency. All surplus water should be thoroughly drained off in every opern. O. P. R. O.

Proper handling of lump lime. ANON. *Contract Rec. and Eng. Rev.*, **37,** 1071 (1923).—When using a quick-slaking lime, if insufficient water is added, the paste is not as plastic and works short. It feels slightly gritty, and has a yellowish tinge. The temp. of the mass is raised considerably above b. p., and a new chem. reaction takes place. This results in a formation of a subs. which absorbs carbon dioxide at a rapid rate, and thus hardens before it may be used. Exactly what this new compd. is, has not been definitely detd., but the result is well known by those who use lime. In the case of "drowned" lime, the excess of water has absorbed too rapidly the ht. for slaking, and the change from quicklime to paste is retarded. When the paste is formed it is thin

and watery and unsatisfactory. A good lime putty, properly prepd. and allowed to age or soak for some time previous to its use, makes a mortar or plaster that is easily applied; aging the paste imparts to it a degree of smoothness not otherwise obtained.

O. P. R. O.

Adhesive for mother-of-pearl, horn and wood. ANON. *Oil & Color Trade Jour.*, **64,** 1444(1923).—An excellent cement can be prepd. by mixing glue, suitably diluted, with a corresponding quantity of strong warm vinegar, adding a certain amt. of ordinary alcohol with a little alum. The cement thus obtained possesses a very great cohesive power, and will keep perfectly fresh in well stoppered bottles. The following process may also be observed: For natural woods, make a cement with a basis of sawdust and glue. For mother-of-pearl and horn, use a cement based on powdered zinc white and floor varnish. O. P. R. O.

Potash and waste heat recovery from cement kilns. ANON. *Chem. Age,* **9,** 442(1923).—A new method of effecting recovery of potash from dust of cement kilns (an English invention) is described. This process presents possibilities in the way of utilizing waste ht. for steam-raising purposes. Expts. have shown that with certain grades of raw mat. some of the dust from the kilns will collect in caked form on hot surfaces. This mat. contains potash salts and other ingredients which make it valuable and may be sold at a higher price than the finished cement. The part of the dust adhering or caking to the hot surfaces has a different chem. compn. from the rest of the dust which will not so adhere, making possible the recovery of the valuable by-product. The mat. is removed from the walls by means of scrapers; from the primary collecting flue hot gases are led through a ht.-absorbing device in the shape of a waste-ht. boiler. Here a considerable reduction in temp. of the gases is effected; their vol. and velocity are likewise reduced and sepn. of the remainder of the dust is facilitated. Because of the cooling of the gases in this way the dry dust separators beyond the boiler have gases of less velocity to handle; the washers through which the gases subsequently pass, operate much more satisfactorily on the cooled gases, as very hot gases tend to evap. and carry away the spray water in the form of steam, and interfere with the satisfactory opern. of the washer generally. The cooled gases are also more readily handled by the fan. In cases where the final removal of the dust is effected by elec. means, the reduction in temp. of the gases is of advantage. O. P. R. O.

Cement from blast furnace slags. ANON. *Quarry & Surveyor & Contractors' Jour.*, **28,** 294(1923).—Recent expts. show that Port. cement may be manufd. from acid blast fur. slags by the addition of certain missing oxides (lime and alumina) to the liquid slag. The best practice is first to add the alumina, then the lime, and thus obtain a very fluid melt, which easily takes up lime. The m. p. remains low for a long time, but the process appears difficult to carry out on account of the high temp. necessary. O. P. R. O.

The French "fused cement (electric)." NITZSCHE. *Zement,* **12,** 142-3(1923).—A tabulation and comparison of the analytical results and phys. properties of "fused cement" obtained by different investigators. R. F. S. (*C. A.*)

Simple cement tests. A. T. FRY. *Commonwealth Eng.*, **10,** 442–5(1923).—In the absence of a testing machine, make test bars 1 x 1 x 10 in. Support them at the ends and apply the load by means of a special hook at the center of the bar. A bucket is suspended from the hook and lead or shot used for loading the bucket. The corresponding tensile strength may then be calcd. from the load and span of the bar.

R. F. S. (*C. A.*)

Relations between volume and strength. H. KÜHL. *Zement,* **12,** 236–7(1923).—The present available data on Portland cement do not permit any relationships to be drawn between the vol. and strength of the cement. R. F. S. (*C. A.*)

Do slags rich in lime give fused cements? C. PRUSSING. *Zement,* **12,** 255–9

(1923).—Mixt. of the ternary system SiO_2–CaO–Al_2O_3, which were all rich in CaO, were studied. The CaO content of slags cannot be increased above 51% without decreasing the hydraulic properties. Cryst. systems below 60% CaO show weak hydraulic properties. R. F. S. (*C. A.*)

PATENTS

Waterproof concrete. A. G. LINDÉN. Swed. 52,563, Aug. 23, 1922. A mixt. of 70–30 parts of cement and 30–70 parts of pulverized brick or talc. (*C. A.*)

Acid-proof mortar. E. S. QVIDINGER. Swed. 52,765, Sept. 20, 1922. An intimate mixt. of cement with finely pulverized chamotte and alum-slate is stirred with a suitable quantity of a soln. of alkali silicate of convenient concn. (*C. A.*)

Treating slag bricks. AKTIEBOLAGET ARCUS BETONGINDUSTRIE. Swed. 53,126, Nov. 29, 1922. The freshly formed bricks are subjected to steam or steam jets to bring about a preliminary binding before the hardening in the air. (*C. A.*)

Cements. H. KONTZLER. Brit. 193,372, Aug. 1, 1922. Slow-setting cements are produced by the fine pulverization of an intimate mixt. of gypsum with aluminates, hydroxides of Al_2O_3 such as bauxite, or natural or artificial pozzuolanas, *e. g.*, blast furnace slag. In the case of a slag contg. less than 30% of SiO_2 and more than 10% of Al_2O_3, 16–20% of gypsum, previously dried at 80°, is used. (*C. A.*)

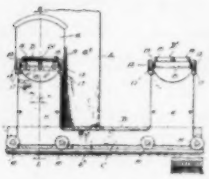
Cements. A. F. MUELLER. Brit. 197,702, May 15, 1923. A hydraulic cement consists of a finely divided mixt. of foundry slag with ferruginous, siliceous, and alumina-, lime-, and magnesia-contg. ingredients in proportions depending upon the compn. of the slag, and with or without clinkers from furnace residues. Clinkers are preferably used which have been freed from coke, etc., by the process described in 146,238, and have thereby become coated with clay, chalk, gypsum, or carbide sludge. Suitable ferruginous addns. are bog ore, Permian limestone, brown ore, Porta stone, ferruginous sandstones, aluminous siderite, slate, ferruginous earths from Paleozoic and Permian formations, finely divided Fe, waste sand dust and sludge from the grinding and polishing of Fe castings, and waste molding sand. Al_2O_3 is furnished by ferruginous clay. MgO is preferably added in the form of mica sand. Suitable calcareous subs. are slaked lime, lime-kiln waste, gypsum dust, and carbide sludge. Artificial stones are obtained by mixing 15 to 25 pts. of the cement with 100 pts. of granulated clinker, breeze, or slag, with or without other filling materials such as sand, pebbles, ground wood, etc. A small amt. of an alkali salt, such as Na_2CO_3, may be added to accelerate setting and increase strength. (*C. A.*)

Enamels

Types of iron and steel which do not rust or ignite. K. DAEVES. *Prazision*, **1**, 270–1; *Physik. Ber.*, **3**, 667–8.—The difficulties encountered in working non-corrodible, high-Cr steels are lessened by reducing the C content and by corresponding heat treatment. Ordinary rust-proof steel consists of about 13% Cr, 0.5% Ni, and 0.7 to 1.0% C. After hardening it has a rigidity of 110 to 170 kg./mm.^{2}, which is not affected by heating to 500°. The coeff. of expansion is 11×10^{-6}. Both heat and elec. condy. are less than that for C steel. Cold work decreases resistance to rusting. Resist. to HCl and H_2SO_4 is not perfect but atm. oxidation does not take place even at 900°. Where special hardness is not required a steel of 13% Cr and 0.1% C is recommended. These steels may be cast, forged, stamped, machined, etc. For surgical or dental instruments a higher Ni content is recommended. All these steels are useful for phys. or chem. app. used at high temps. Their cost is about 10–12 times that of ordinary steel. A. E. S. (*C. A.*)

PATENTS

Charging fork for enameling furnaces. WILLIAM HOGENSON. U. S. 1,471,028, Oct. 16. Charging means for enameling fur. comprising a traveling, wheeled carriage, two widely spaced sets of track bars secured on said carriage, and two fork frames mounted on rollers that travel on said track bars, each fork being movable independent of the other, and there being free and unobstructed loading and unloading passages between said sets of track bars, and between said fork frames, whereby either fork frame may be loaded and unloaded from either side.



Method of cementation of boron into the surface of iron or steel. TAKEO MIYAGUCHI. U. S. 1,472,850, Nov. 6. A method of cementation of boron into the surface of iron or steel comprising covering the desired surface of the iron or steel with a mixt. of carbon powder and boron oxide or compd., and heating it at from 800°C to 900°C in a reducing atm. Brit. Pat. 193,917, Nov. 3, 1921.

Method of cementation of boron into the surface of iron or steel. TAKEO MIYAGUCHI. U. S. 1,472,851, Nov. 6. A method for the cementation of boron into the surface of iron or steel, comprising placing the iron or steel within a closed fur., covering the portion desired to be cemented with a finely powdered boron contg. mat., shielding the remaining portion with iron plate, iron powder, clay or the like to prevent cementation action of boron, and heating the iron or steel for a considerable period, at from 800–900°C in the presence of chlorine gas. Brit. Patent 193,918, Nov. 3, 1921.

Enamels. CHEMISCHE WERKE VORM. AUERGES. Brit. 197,933, May 10, 1923. To prevent opaque enamel from bubbling during firing, a portion of the clay which is usually added to the mill is first made incandescent and then added to the other ingredients. One-half of the clay may be so treated, and the process is stated to be particularly applicable when Zr or Ce oxide is present. (*C. A.*)

Glass

Table of Belgian patents in the glass industry. J. GEVERS AND CO. (Antwerp). *Le Verre*, **3**, 200–1(1923).—The "Dictionary of Patents" listing the number of patents granted in Belgium from 1830 to the end of 1922 contains a list of patents relating to the glass indus. The table contains 2847 patents subdivided according to 62 classifications: as "fusion of glass" 182 patents, "reinforced glass" 19, "optical glass" 1, etc. About $^1/_3$ of these patents are of Belgian origin, the remainder of foreign origin, especially Amer., Eng., French and Ger. L. N.

Furnaces for melting glass. H. MAURACH. *Glass Worker*, **43** [1], 11(1923); (from *Fuels and Fur.*, Aug., 1923).—The Ger. Advisory bureau report of 1921–1922 on tanks and pot fur. In older fur. the depth of the bath is 27.6 in. Newer practice is 43.3 to 47.2 in. deep. 59.4 in. is the max. Low flat roofs are now used. For a span of 21.3 ft. the rise of the arch is 29.5 in. The distance from the crown to the bath is 5.2 ft. The arch is 10 to 14 in. thick. 4 to 6 inches of glass can be melted and taken out every 24 hrs. Gas ports are discussed and a table of dimensions given for the size of ports for various sizes of pot and tank fur. Sketches of fur. design are given. There should be 2.6 to 4 cu. ft. of checker work per cu. ft. of fur. vol. for tanks. Pot furnaces require two times these values. R. J. M.

Gas producer practice. W. B. CHAPMAN. *Glass Worker*, **42**, 39, 11(1923).—The ht. balance on a gas producer, with the method of calcn., is given in detail. R. J. M.

The manufacture of optical glass. C. J. PEDDLE. *Trans. Opt. Soc.* (London), **23**, 103(1922).—This paper describes briefly the history of optical glass manuf. from the

earliest attempts to date. The present methods of manuf. in Great Britain are then described in more detail. Only 50% of the glass usually passes the preliminary inspection and if 20% of the total is usable after finishing, the melt is considered satisfactory. The yield is often under 10%. "The only sure method of testing for fine striae in glass

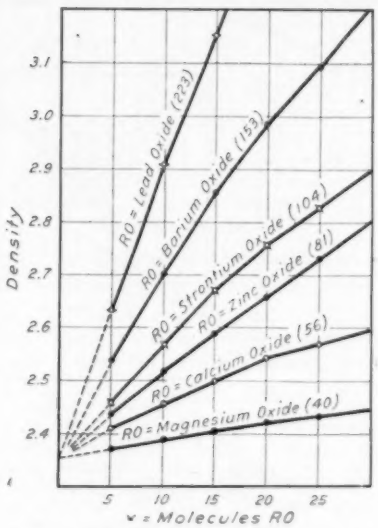


FIG. 1.—Molecular composition and density in the series 100 mols. SiO_2 . 20 Na_2O . xRO.

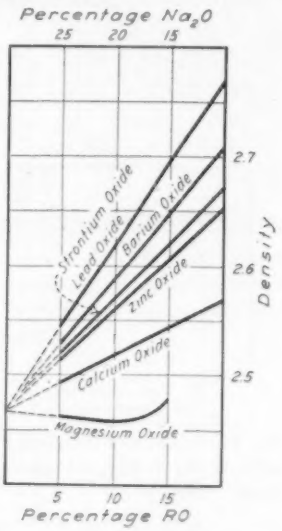


FIG. 2.—Percentage composition and density. (Silica constant = 70%.)

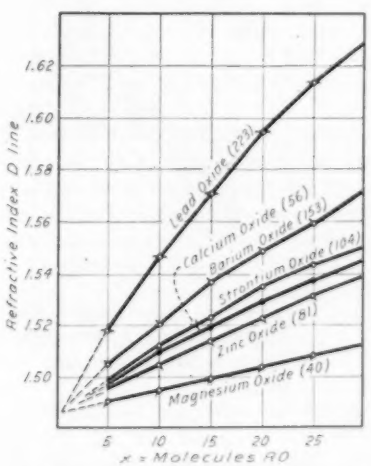


FIG. 3.—Molecular composition and refractive index (μ_D) in the series 100 mols. SiO_2 . 20Na_2O . xRO.

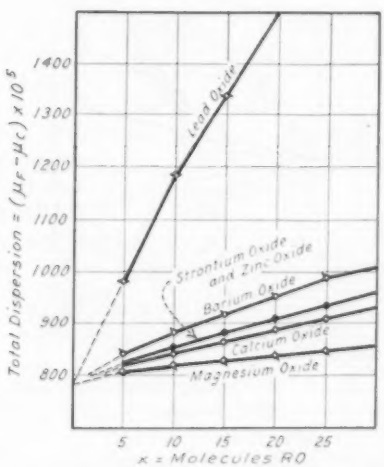


FIG. 4.—Molecular composition and total dispersion in the series 100 mols. SiO_2 . 20 Na_2O . xRO.

is the examn. of pieces of glass, polished on opposite faces, by means of a polariscope." The author has studied the influence of compn. upon density, refractive index, durability and tendency to devitrification (cf. *C. A.*, **14**, 2536; **14**, 2509; **15**, 2966; **16**, 620; **16**, 3180), and these are discussed. The effect of diff. oxides on the d. of glass depends on the mol. wt. of the oxides. In glasses of compn. 100 SiO_2 . 20 Na_2O . 10 RO the densities and mol.

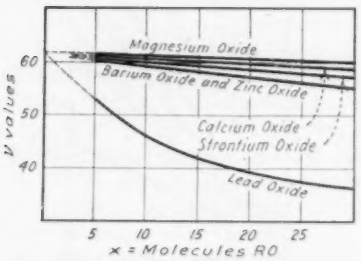


FIG. 5.—Molecular composition and ν value in the series 100 mols. SiO_2 . 20 Na_2O . xRO.

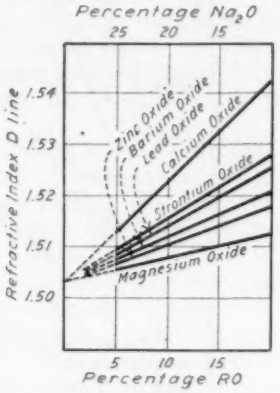


FIG. 6.—Percentage composition and refractive index. (Silica constant = 70%.)

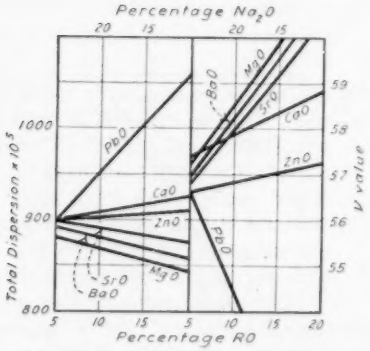


FIG. 7.—Percentage composition and total dispersion. (Silica constant = 70%).

FIG. 8.—Percentage composition and ν value. (Silica constant = 70%.)

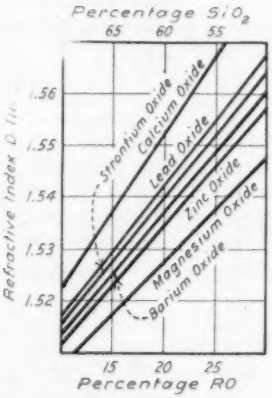


FIG. 9.—Percentage composition and refractive index. (Sodium oxide constant = 20%.)

wts. are in the following order: RO = PbO (223), BaO (153), SrO (104), ZnO (81), CaO (56), MgO (40), densities of glasses are 2.91, 2.71, 2.57, 2.52, 2.46, and 2.39, respectively. The curves illus. the connection between the phys. properties and chem. compn. of glasses. Durability of the glasses was tested by the action of water at 80°C on the

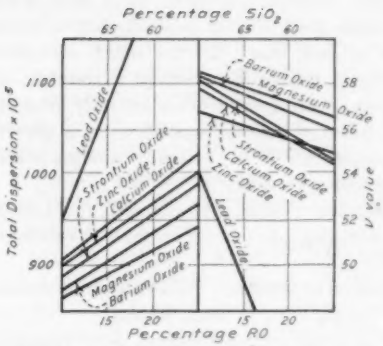


FIG. 10.—Percentage composition and total dispersion. (Sodium oxide constant = 20%.)

FIG. 11.—Percentage composition and ν value. (Sodium oxide constant = 20%.)

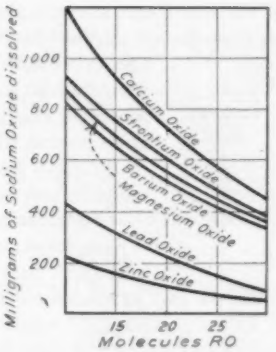


FIG. 12.—Molecular composition and solubility of glasses. 100 SiO_2 . 20 Na_2O . xRO.

powdered glass. ZnO has the greatest effect on improvement of durability when replacing SiO_2 or R_2O wt. for wt. The RO oxides improve durability in order of their mol. wt., MgO being best and PbO worst. Photographs are given of crystals formed in the devitrification of glasses. The paper includes a short bibliography of modern papers on optical glass. *Ceram. Abs.*, **1** [4], 111 (1922); **1** [6], 165-6(1922). D. E. S.

Preheating glass batch. A. FERGUSON. *Glass Worker*, **42**, 39, 15(1923); (from *Pottery Gaz. and Glass Trade Rev.*).—The batch, ground to 60 mesh and preheated to 850°C to free it from CO_2, is introduced into the tank at the rate of 2 lbs. per sec. Waste ht. is used for prehtg. R. J. M.

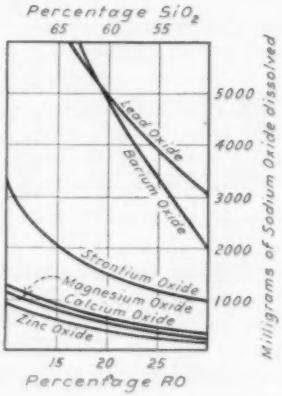


FIG. 13.—Percentage composition and solubility. Sodium oxide constant = 20%.

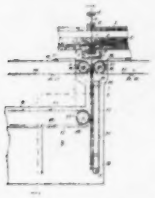
Specifications for glazing glass. ANON. *Glass Worker*, **43** [4], 9(1923).—Specif. are published by the Bureau of Standards, assisted by the manufacturers, covering plate, window, processed, rolled figured, wire, ornamental and prism glass. Nomenclature and definitions are also given. R. J. M.

Continuous sheet glass machine. ANON. *Glass Worker*, **43** [5], 9(1923).—A new flow device produces flat sheet glass of any thickness. A continuous sheet 365 ft. long and 40 in. wide goes through the leer. Installation at the plant of the Licking Window Glass Co. is described. R. J. M.

PATENTS

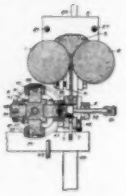
Method and apparatus for forming sheet glass. HUBERT A. MYERS. U. S. 1,471,189, Oct. 16. In an app. for forming sheet glass, a tank for containing molten glass from which glass may flow continuously in sheet form, means for successively feeding end strips in pairs to the opposite edges of the sheet being formed lengthwise of the movement thereof in adherence therewith, means for successively applying upper and lower sets of cross bars to the upper and lower ends of each pair of edge strips and

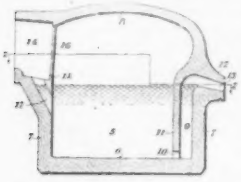
to the sheet to coöperate with the edge strips to embrace a predetd. sheet area, means for guiding the vertical movements of the frame sheet section and adapted to release the upper and lower ends of each frame for horizontal movement when it has reached a predetd. point in its vertical movement, and means for engaging and moving each frame section laterally from the guide means when in side delivery position and to effect a severing of the sheet between the upper end of the laterally moving section and the lower end of a succeeding section.



Paste for etching glass. LEO SIMON. U. S. 1,470,772, Oct. 16. A paste for etching glass, containing ammonium sulphate, hydrofluoric acid and a liquid mucilage.

Process and apparatus for producing spectacle blanks. FREDERICK GELSTHARP. U. S. 1,471,725, Oct. 23. Apparatus for producing glass articles, means for generating a sheet of glass continuously in a downward direction, a plunger mounted beneath said means for movement transversely through the sheet, and a drum mounted for rotation in opposition to the plunger and provided in its periphery with a series of mold recesses adapted to be brought successively into alignment with said plunger to receive the articles, means for continuously operg. the rolls and means for intermittently operg. the plunger and drum.





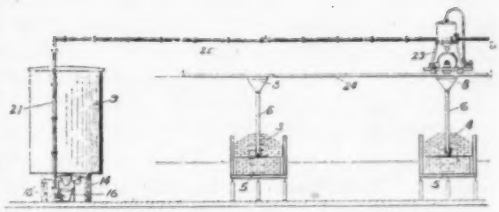
Glass-melting pot. CLINTON A. BOWEN. U. S. 1,471,824, Oct. 23. A glass-melting pot composed of a body closed at the top and having a mouth near the top thereof and projecting therefrom, said mouth being provided with a door, and an opening formed in the bottom of said mouth and communicating with said body below said door, said opening being so positioned that molten glass can be fed into the body below the normal working level of the glass therein.

Blowpipe for glass-making apparatus. JOHN CARMANY CAMPBELL. U. S. 1,472,291, Oct. 30. A device of the character described comprising a hollow body open at its lower end, said body having oppositely disposed flat walls positioned close together and connected at their ends, an inwardly extending horizontally disposed flange at the lower end of the walls of said body terminating in an inwardly and upwardly extending lip, and an air pipe extending from the top portion of said body.

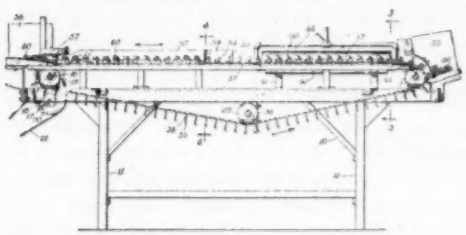
Glass. CHANCE BROS. & CO., LTD. and A. L. FORSTER. Brit. 197,590, April 11, 1922. Relates to glass of the kind in which Fe_2O_3 is combined in the ferrous state to enable the glass to act as a good absorber of thermal radiation. According to the invention, the propn. of Fe_2O_3 is such that the amt. of FeO per unit area of the glass will give the desired absorption and transmission of thermal and luminous radiations. *E. g.*, hammer scale or Fe oxalate is added in such quantity that the finished glass sheet contains about 0.01 g. of FeO per sq. cc. of surface. It is found that with such a glass, the ratio of luminous radiation transmitted to thermal radiation absorbed is a max. and the glass is suitable for window and roofing purposes in hot countries. (*C. A.*)

Raw-material conveyer for feeding glass furnaces. WILBUR F. BROWN. U. S. 1,473,008, Nov. 6. The method of feeding raw mat. from a common source of supply to a plurality of glass melting furnaces, consisting in drawing the several materials by suction through a conduit to the vicinity of any selected furnace, there mixing the materials together, and then delivering the mixed batch directly to the fur. An app. for conveying raw mats. from the storage tanks to a plurality of glass melting fur.,

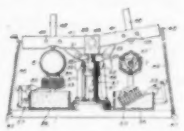
comprising a conduit extending from the storage tanks to the fur., means for feeding the mats. from the tanks to the conduit, means for drawing the mats. through the conduit by suction to any selected fur., and means for there delivering the mats. from the conduit to the fur.



Glazing machine. HANS N. HALVERSEN. U. S. 1,473,675, Nov. 13. In a glazing appliance of the character described, the combination of two htg. means positioned to successively heat the opposite ends of the bodies treated, a guide-plate for each of said heating means, a support having portions sloping in opposite directions toward said guide-plates, and a pair of parallel endless conveyor chains equipped with forwardly bent fingers to engage and roll the inclined bodies to be glazed along said support first with one end against one guide-plate and the opposite end subject to the action of the corresponding heating means, and subsequently with the glazed end against the second guide-plate and the other end in a position to subject it to the action of the second heating means, said support and bent fingers maintaining in each instance the end being glazed in advance of the end bearing against the guide plate substantially as described.



Glass-banding machine. JAMES BOYD GREER. U. S. 1,473,762, Nov. 13. A cutting machine comprising an intermittently rotating chuck adapted to receive the article to be cut, means for actuating the same, a cutter carrying arm mounted adjacent said chuck, a cutter thereon, said cutter arm being pivoted to a supporting head, said head and cutter arm being freely removable from the machine as a unit, and automatic means for moving the cutter into and out of engagement with the said article.



Heavy Clay Products

Brick made from coal bearing schist. G. HERMANT. *Rev. Mat. Constr. Trav. Pub.*, **168,** 209(1923).—Ground schist contg. 4, 6, and 8% carbon was made into brick by the sand-lime brick process with slaked lime in propns. of 4, 6, 8 and 10%. Satisfactory brick were made with schist contg. not more than 6–7% combustible carbon, and with 4–8% lime. The max. crushing strength of 120–130 kg. per sq. cm. was obtained with schist contg. 4% carbon, schist with 6% carbon giving 105 kg. per sq. cm. Porosity ranged between 8 and 11%. L. N.

Brick and tile works ("La Bédaricienne" at Bédarieux (Herault, France)). J. E. D. *Rev. Mat. Constr. Trav. Pub.*, **168,** 161–6B(1923).—Description of plant, with 2 drawings and 4 photos. Two kilns are in service (1) a Hoffmann continuous kiln 43 m. long with chambers 2.60 m., having a coal consumption of 120–130 kg. per 1000 brick (5 x 11 x 22 cm.) with a daily product of 25,000. (2) a semi-continuous kiln 20 m. long, with chambers 3 m., producing 4,000 brick daily with a slightly higher coal consumption than (1). L. N.

Arlington building. LOUIS J. LARSON AND SERGE N. PETRENKO. Bur. Stand.,

Tech. Paper **236.**—The hollow tile and reinforced concrete floors of the Arlington Building, Washington, D. C., were loaded and the deformations measured. This was, at the time, the first test upon this type of construction in which strain-gage meas. were taken. The floor slab was formed by rows of hollow tiles spaced 4 in. in each direction. The reinforcing steel was placed in these spaces and concrete poured around it and into the open ends of the tiles. The columns are steel H-sections surrounded by a thick casing of concrete. The beams and girders have steel I-beams encased in concrete. These beams are generally near the bottom and may be considered the tension reinforcement. The panels, having various ratios of length to width (from 1.05 to 1.86) were loaded with sand bags, separated by aisles to prevent arching, some up to 380 lb./ft.^{2} The loading schedule was intended to produce max. positive and max. negative moments and to enable the study of the effect of transferring load to an adjacent panel The max. stresses developed in the slab were about 27,500 lb./in.^{2} in the negative reinforcement and 24,000 lb./in.^{2} in the positive reinforcement. Both stresses were developed at the load of 335 lb./ft.^{2} The stresses developed in the reinforcing I-beams of the girders were lower. The max. recorded compressive stress in the concrete was about 1,600 lb./in.^{2} The distribution of the cracks in the concrete furnished an indication of the distribution of the stresses at an early stage of the test. The first cracks observed were diagonal ones on the bottom of the slab. They occurred at about the same time as the cracks on the top which extended across the corners and at right angles to those on the bottom. The cracking of the concrete was accompanied by a considerable increase of the stresses in the reinforcing steel. The study of the cracks and the stresses shows that in a test of this kind, the deformations, though measured at positions of max. moment, will fall far short of showing the max. stresses unless the gage lines are located across or very close to the principal cracks. Thus, in some cases, the stresses observed at positions of max. moment and at the gage lines crossed by cracks were 16,000 and 23,000 lb./in.^{2}, while stresses in gage lines 12 in. from the cracks were 4,000 and 5,000 lb./in.^{2}, respectively. The effect of time under load was very pronounced in the first 20 hours and comparatively small later The effect of increasing the ratio of the length to the width of the panel was to increase the moments carried by the positive and the negative reinforcement in the short span and a corresponding decrease of the moments in the long span. The beams offered very little resist. to torsion and the stresses in the negative reinforcement across the beam were little affected by the transfer of load across the beam. The increase of the deformation in the reinforcement due to long continued loading was greater than that in the concrete. This probably was partly due to the assistance of the clay tiles in resist. the compressive deformation because of the clay tiles yielding less than the concrete. The moment coeff. are generally small due to the low stresses and are not proposed for use in design but to show the rel. amt. of bending moment carried in the 2 directions. From the comparison of these results with those obtained from tests of simple beams, it appears that the factor of safety of the construction is the greatest. H. F. S.

Remarkable new brick-making process. ANON. *Times Trade & Eng. Supplement* (London), **13,** 133(1923).—This new process consists in the thorough disintegration and drying of the particles of the mat. as a first opern. The saving of time is obvious, for after 15 min. the dried and finely granulated clay passes to a moistening device wherein a complete stirring, without compression, combined with a projection of fine particles of water, converts the dry clay into a pulverized mass which is perfectly and regularly moistened to the exact deg. required. The amt. is then led into hydraulic presses, and on leaving these a brick placed edgewise is of sufficient strength to support the wt. of 2 men standing upon it. The bricks are then baked, 80% being suitable for facing bricks. *Time:* One series of machinery can produce from

3,500 to 4,800 bricks per hour. *Labor:* The labor needed in the new process as compared with the old-fashioned wet process is as 7:22. *Cost:* The comparison of the approx. cost per thousand is as 13:21. The finished product has 50% more resist. to press., frost, and chipping. In matter or economy, this is a process by which brick and tile may be made, superior in quality, at a cheaper rate, with less labor and time; it is possible to make brick and tile from mats. which have hitherto been considered useless for such manuf. O. P. R. O.

New invention for bricklaying machinery. ANON. *Times Trade & Eng. Supplement* (London), **14,** 9(1923).—This new bricklaying mach. is in opern. on a large housing scheme in Glasgow. The average number of bricks laid per hr. is 1,300, as compared with the bricklayer's av., 800 per day. The mach. is known as the K erector, and consists of a traveling rail, by means of which the portion designed to lay bricks is enabled to travel in 2 directions, at right angles to one another. By this means a circuit of the outside walls is made, the mach. laying the bricks as it goes. A special device checks the opern. at door and window openings, and the internal walls are erected in the same manner as the outer walls. The laying wheel rotates, taking 2 bricks at a time from the hopper, the mortar measg. wheels spread the mortar, and the carriage moves along the overhead traveling rail, thus laying a row of bricks as it goes. O. P. R. O.

PATENTS

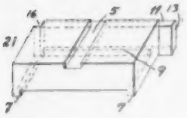
Clay-working machinery. ROY H. MCELROY. U. S. 1,471,405, Oct. 23. The combination with a motor, of a shaft, belting connecting the motor and shaft, a pinion on said shaft, a second shaft, a gear on the second shaft, meshing with said pinion, an extrusion auger carried by the second shaft, an impeller positioned laterally of the auger and adjacent thereto, and means to drive the impeller from the second shaft.

Method of forming interlocking bricks. JOHN T. ROBERTS and JESSE C. MARTIN, JR. U. S. 1,471,506, Oct. 23. The method of forming plastic clay into bricks with bosses and recesses, which bricks when laid with the bosses in the recesses form interlocking wall, consisting in taking a cut block of plastic clay of the same size that would normally form a pressed brick without bosses and recesses, and subjecting the block to press. in such manner that recesses are formed on one face of the block deeper than the height of the bosses on the opposite face by the displacement of clay from the recess side to the boss side of the block.

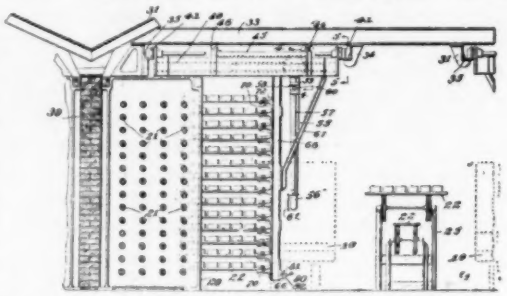
Process for applying vitreous and waterproofing coating to brick and burnt-clay articles. JOSEPH H. HINES. U. S. 1,471,792, Oct. 23. A process for applying vitreous and water-proofing coating to certain of the surfaces of burnt clay articles, consisting in first coating the surfaces of the articles which are not to be coated with the vitreous and water-proofing coating, with clay or kaolin, then baking the articles in a fur. to approx. a red ht. then withdrawing the articles from the fur., then sprinkling powdered vitreous and water-proofing compd. upon the surfaces of the articles which are not coated with the clay or kaolin, and allowing the ht. of the articles to melt or fuse the powdered vitreous and water-proofing compound and permit it to spread over and adhere to the surfaces of the articles which are not coated with the clay or kaolin, then allowing the articles to cool, and finally removing the clay or kaolin from the same.

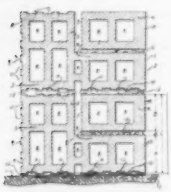
Interlocking building brick. JAMES HUNDLEY. U. S. 1,472,911, Nov. 6. A bldg. brick formed with a plurality of depending lugs in spaced relation to one another on one horizontal face of said brick, a vertical lug adjacent one end of said brick adjacent the exterior face of the brick, a vertical recess on the opposite end of said brick in alignment with said vertical lug, a transverse recess in the surface opposite said depending lugs and in spaced parallel relation to said depending lugs, a plurality of bonding

recesses on the interior face of the brick, said vertical lug projecting to a greater extent than the depth of said vertical recess, and said depending lugs projecting to a greater extent than the depth of the transverse recess, a longitudinal depending lug in alignment with said vertical lug and connecting one extremity of said first mentioned depending lugs adjacent the exterior face of the brick, a longitudinal recess on the opposite edge of said exterior face so positioned that when a series of said brick are laid together to form a wall the exterior face of said wall will form a continuous smooth surface while the interior face will possess spaced recesses between adjacent bricks, except where said lugs engage said recesses, essentially as and for the purpose described.



Brick-pallet-handling apparatus. GRAFTON E. LUCE. U. S. 1,473,305, Nov. 6. Apparatus of the kind described, comprising a movable support, a plurality of clamps carried by said support, said clamps being spaced approx. equal to the distance between the pallet receiving pipes in a steam pipe drier, and means for moving the clamps to engage and hold a plurality of pallets under substantially equivalent holding tension.





Building tile. CHARLES H. TOFFELMEYER. U. S. 1,475,092, Nov. 13. A wall structure comprising main tiles and a filler tile associated with each main tile, each filler tile situated within a recess in a main tile, the tiles being so formed that the cross-section of each pair of assembled main and filler tiles is rectangular.

Refractories

Refractory materials of the London Basin. HENRY DEWEY. *Trans. Ceram. Soc.* (Eng.), **22** [1], 38(1922–23).—By the London Basin the geologist means that part of the S. E. of England which is practically the same as the Thames Basin. The chalk supplies very little mat. of a refrac. nature. Of the Tertiary beds the Thanet sands supply mats. used in the manuf. of lime-sand bricks, and as casting and molding sands. The most remarkable deposit consists of loamy sand of a greenish grey to white tint and varies in thickness up to 5 ft. Refractory wares, used at many of the London and other gasworks, are made from this material. The principal brick-earths form wide-spread tracts at about 90 ft. and 50 ft., respectively, above sea-level. Most of the large brick fields, which formerly supplied London with its bldg. bricks, were in the alluvial brick-earths. H. F. S.

Effect of salty clay upon refractory materials. L. M. WILSON. *Chem. and Ind.*, **42,** 1009(1923).—In a paper read before the Ceramic Soc. (London), Oct. 4, W. said: After he had investigated the action of ammonium chloride, which is found in coke-oven gas from salty coal, he concluded that: (1) There is a critical temp. at about 900°C, at which the chem. properties of burned fire clay seem to undergo a change, quite apart from the critical temps. at which the phys. properties of either raw or fired mats. are known to alter. Below this temp. very little alumina is removed, and above it a great deal of alumina is removed by the action of htd. ammonium chloride. (2) The exptl. evidence demonstrated the superiority of high-grade silica over fire clay for the lining

of coke ovens as regards resist. to salty coal. (3) At temps. from 700°C to 1200°C and higher, ammonium chloride removes iron and alumina from fire clay and from silica bricks. O. P. R. O.

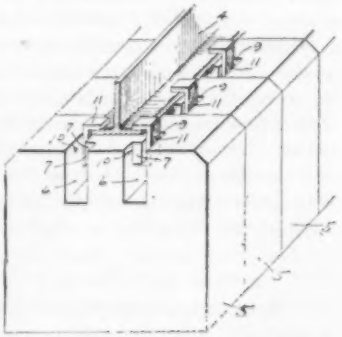
Sillimanite: a high-grade refractory. ANON. *Bull. Imperial Inst.*, **21**, 383(1923).—It is found commonly in gneisses and cryst. schists and in detrital rocks derived from them, usually disseminated in grains or aggregates of fibres. Recently it has been found in India in the massive variety which is very rare. The deposit is in the Khasia Hills of Assam and is in the form of boulders. Experimental work is being carried on by the Imperial Inst. as to its value as a high grade refrac. mat. and if it is successful an attempt will be made to overcome the difficulties of transport and place it on the market. Its valuable properties as a refrac. are strength and toughness, high m. p. (about 1810°C) and stability up to that temp., low coeff. of expansion, low elec. condy., freedom from vol. changes, neutral reaction, and resistivity to corrosive slags and to oxidizing and reducing conditions. Its use is still in the exptl. stage. The Amer. Refrac. Co. in conjunction with the Mellon Institute have also carried out expts. along this line. Though its first cost would be higher than that of less refrac. mats. it is probable that its greater durability will more than compensate for the difference. O. P. R. O.

The importance and future of the German graphite output. E. H. SCHULTZ. *Chem.-Ztg.*, 685(1923); cf. *C. A.*, **17**, 3074.—The Bavarian graphite production increased from 4,000 tons in 1907 to 36,000 tons in 1918, while the Austrian production fell from 50,000 to 32,000 tons, and that of Ceylon from 35,000 to 22,000 tons during the same period. Between 1891 and 1913 German imports rose from 13,000 to 44,000 tons. Because of excellent methods of treatment it is claimed that the local (German) varieties of prepd. graphite are superior to those obtained from other sources, chiefly because they come in flakes rather than in powder form. W. C. E. (*C. A.*)

Refractory materials for the construction of furnaces. THOMAS. *Giesserei-Ztg.*, **10**, 235–7(1923).—Unreliable results are obtained in the detn. of the refrac. quality of a mat. by the Seger cone method, because the stone softens at much lower temps. Far superior is the method of Endell (no reference). The valuation of mats. by this method and their use in fur. construction are discussed. C. C. D. (*C. A.*)

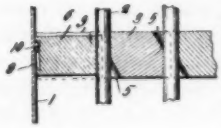
PATENTS

Refractory article. EDWIN B. FORSE. U. S. 1,473,286, Nov. 6. A refrac. article contg. silicon carbide grains having its surface pores filled with finely divided silicon carbide.



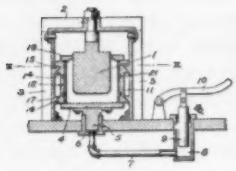
Furnace arch. CLARENCE A. STRACHOTA. U. S. 1,472,945, Nov. 6. The combination with a flanged beam and a block structure in which said blocks are formed with pockets having undercut ledges forming contracted throats of block hangers arranged in opposing pairs and having outer flanges slidable on the beam flange and having inner flanges slidable under the undercut edges of the blocks.

Baffle brick. FRANK H. WAITE. U. S. 1,473,132, Nov. 6. In combination, a pair of walls, a plurality of bars situated between the walls, a plurality of bricks supported between the bars, each brick provided with channels at its ends, said channels being deeper at one of their ends and said deeper portions being diagonally disposed in relation to the bricks, and a plurality of bricks situated between the bars and the walls,



lugs provided on the walls, said latter mentioned bricks each provided with a channel in one end for engaging one of the bars and a bayonet slot in its other end for engaging one of the lugs.

Apparatus for forming clay pots. CLAUDE H. MCCUTCHEON. U. S. 1,473,791, Nov. 13. In combination in apparatus for forming clay pots, a base plate, a plurality of side wall members mounted slidably on the base plate for radial movement, a downwardly extending core in the upper portion of the cavity formed by the side wall members, a framework for holding the core against upward movement, power means for moving the base with the side wall members thereon upward, and coöperating on the means framework and side wall members for causing an inward movement of said members when such side members are moved upward by said base plate.



Refractory compositions. R. SCHAEFER ET CIE AND H. SCHAEFER. Brit. 196,021, Dec. 13(1921). Refractory compns. for making metallurgical or other fur. by molding are prepd. by grinding waste siliceous bricks that have been used in furnaces or quartz that has been heated until crystn. transformation has taken place, and mixing with an organic binder. Suitable propns. are 100 pts. of powder to 5 pts. of binder. Binders specified are non-hygroscopic org. agglutinants sol. in H_2O, such as dextrin, amylaceous materials, albuminoids, glucosides, glucoses, gelatins, and sulfited liquors or residues; and carbonaceous mats. such as resin or asphalt. The compn. is mixed with H_2O, naphtha, or other solvent of the binder, molded, and dried, and is baked *in situ* by lighting the fur. (*C. A.*)

The production of porcelain for electrical insulation. IV. F. H. RIDDLE. *Jour. Amer. Inst. Elec. Eng.*, **42**, 743–7(1923).—Modern methods of prepg. the plastic body are described. The stock of raw materials should be large enough to permit sampling and testing before using. Some ingredients such as ball clays hold water tenaciously, and it is well to store such mat. wet. Hence, in weighing out the batch, it is necessary to det. and allow for the percentage moisture in each ingredient. The old method of blunging, which merely disintegrates the lumps without reduction of size of the particles, is to be avoided. Wet grinding in the ball or pebble mill produces a better porcelain, if properly controlled, but care is necessary, since the quality of pebbles and lining, speed of revolution, total time of grinding, proportioning of volume of clay to volume of pebbles, and the quantity of water all have a decided influence on the resultant grain sizing. After passing the slip over a magnetic separator to remove magnetic iron, it is then passed through a lawn of 120 meshes per in., to eliminate coarse particles, and filter pressed to eliminate excess water, yielding a plastic body of approximately 22% water. The filter press cakes are stacked in a cellar to age. This increases plasticity and provides time for testing mat. before it is released for production. Pugging the filter press cakes after aging distributes the moisture more uniformly, but may lead to trouble, due to lamination (both die and auger). A. F. G.

Whitewares

Manufacture of English chemical porcelain. G. N. WHITE. *Chem. Age* (London), **9**, 334(1923).—W. gives the results of his research in the field of chem. porcelain which is now being produced commercially and successfully. He deals with the scien. basis of the work; the problem of producing a hard porcelain which will carry a hard insol. glaze, will show a high resist. to fracture on sudden temp. change and at the same time be perfectly vitrified and impermeable to gases below 1300°C; also the general ceram. procedure. He deals with chemical porcelain in some detail as to compn., types of

fracture etc., with photographs of body and glazes of Royal Worcester Lab. Porcelain O. P. R. O.

A study of factors involved in slip-casting. S. R. HIND. *Trans. Ceram. Soc.* (Eng.), **22** [1], 90(1922-23).—The general effect of alterations on the nature (quality) of the casting are: less alkali in the slip; higher slop weight; and lower temp.; all seem to operate in the same direction, *i. e.*, to give a softer, more plastic and thicker casting. H. F. S.

Atmospheric conditions in potters' shops and the efficiency of various types of drying stoves. H. M. VERNON. *Trans. Ceram. Soc.* (Eng.), **22** [1], 70(1922-23).—The high temps. appear to have been due largely to the wishes of the potters themselves. There can be little doubt that they render themselves more susceptible to cold. The very great mortality of potters from phthisis and other respiratory diseases is generally attributed to the inhalation of pottery dust, but it may be due in no small degree to the high temp. and lack of ventilation. The potters' shops investigated were badly underventilated. The humidity of the air in potters' shops is approx. the same as that observed in other shops. H. F. S.

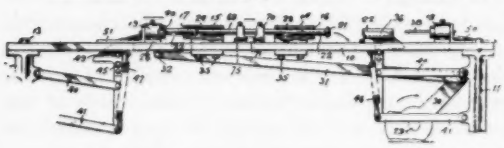
Some experience with the Dorr mill in grinding quartz and flint for pottery purposes. A. S. W. ODELBERG. *Trans. Ceram. Soc.* (Eng.), **22** [1], 1(1922-23).—The mat. is first crushed by means of an ordinary stone breaker fitted with a screen of about 1 cm. mesh, the fragments not passing through being automatically returned to the crusher by means of an automatic conveyor. Ten tons are crushed in about two hours. This crushed mat. is now conveyed to a hopper with a capacity of about 10 T. At the bottom of this hopper is an automatic disk-feeder which can be adjusted to deliver the exact amount required. This continuously feeds the mat. into a trough where it is moistened and intimately mixed with semi-ground mat. returning from the plant. A scoop feeder, fixed on the rotating shaft of the tube mill, gradually works this mixt. into the mill through the hollow shaft by means of a worm. The mill is lined and filled with pebbles in the usual way. At the other end of it there is a hollow shaft, also provided with a worm, which both retains the pebbles and discharges the partly-ground pulp. A strong jet of water pushes this material into what, in the mining industry, is called a launder, which is simply a wooden trough. The pulp, being very much diluted, runs quite freely by gravitation through this trough into the classifier, in which, by means of rakes, the coarsest mat. is returned to the scoop-feeder to repeat the same round, while the finer pulp flows over into a sump, from which it is lifted by a centrifugal pump to the story above into a tank filled to the very top with water. This tank is called a hydro-separator. The coarser pulp runs out at the bottom through an adjustable tap, and it is divided into two parts, one returning to the launder mentioned above, and the other part to the scoop feeder trough to provide the requisite moisture to the material before entering the mill. The finer pulp flows over the brim of the hydro-separator in a fine film and then passes through a 130-mesh lawn to remove any particles of wood or coal dust. The amt. is very small, the lawn requiring to be cleaned only once in 12 hrs. The fine pulp now gravitates through a trough into the middle of what is called the thickener, which is a round tank of 16 ft. diameter and about 10 ft. high, filled to the very brim with water, the top edge being dead level all round. Between this and an outer edge is a groove 3 or 4 in. deep, and of the same width, to collect the overflow. This groove is, at a certain point, connected with a pipe which conducts the overflow of practically pure water to the point where it forms the jet, which forces the pulp coming out of the tube mill into the launder and so to the classifier. Thus the circuit is completed, the same water being used over and over again, apart from what remains in the finished slop mat., which is run off through a tap from the bottom of the thickener and conveyed by gravitation to the flint ark. To replace the water going away with the finished material into the flint ark, a small jet of water from the main runs into the

launder at the discharging end of the tube mill. The rate of grinding at present is about 7.2 T. per 24 hrs. or about 11 lbs. per min., dry wt. The thickness of the pulp as it leaves the tube mill is 1.6 sp. gr. or 32 oz. to the pint. To retain this precise thickness is of the greatest importance, as it makes for the smooth working of the mill. To make it thicker would reduce the output, as the flint pebbles then get clogged in the stiff material, and fail to do their work, the actual grinding then only taking place in contact with the lining. It will not do to dilute the slop mat. in the mill too much, as the pebbles then sink to the bottom, do not mix with the mat. and punish the lining. Should a coarser mat. be required, say particles under 0–01 mm. 52%, particles between 0–01–0.025 mm. 34% and particles from 0.025–0.04 mm. 14%, which is generally used in the potting trade, the output can easily be increased to about 10 T. in 24 hrs. H. F. S.

Continuous grinding. C. J. MOLLER. *Trans. Ceram. Soc.* (Eng.), **22** [1],12(1922-23).—The hard raw mats., flint, feldspar, stone, etc., are first crushed in an ordinary jaw crusher. The preliminary crushing plant runs automatically without any attendance until the bin is empty. From the feeding device the mat. enters a roller mill, crushed to pass mesh No. 10, passes a magnetic separator and a rotary sieve. The hard mats. are weighed out from the different bins in the correct propns. for one charge of the mill, and ground down for about 2 hours with the necessary amt. of water. The soft mats. (clay, china clay, etc.) are filled in, and all the raw mats. are ground together for a quarter of an hr. to ½ hr., after which the whole contents of the mill are emptied out as ordinary slip. From the mill the mat. passes over a magnetic separator and a control screen where impurities are retained, and from here we ordinarily run the slip down into big, reinforced concrete hoppers, where it is stored for some time, as it appears that a maturing of the slip takes place when it is kept as a well-ground mixt. for some time in big storage basins. To avoid pptn., the slip is kept agitated from time to time by means of compressed air blown through it. The filter pressing takes place in the foll. way: The slip runs by gravity from the reinforced concrete hoppers down into sheet iron receivers, from which it is forced into the filter presses by means of compressed air. In filter pressing by compressed air, the necessary time is reduced to about half the time ordinarily required for this operation, and at the same time the compn. of the filter press cakes becomes more even, as no blows from a piston reach the slip; and further, the durability of the filter cloths is prolonged, as the blows from filter press pumps seem to have a bad effect on them. H. F. S.

PATENT

Machine for heading porcelain tubes and the like. ALBERT G. MASON and LORENZO C. BUCKLEY. U. S. 1,471,907, Oct. 23. In a tube-heading mach., a stationary die, a movable die coöperating therewith, a feed table adapted to support a tube blank in substantial alignment with said dies, and means associated with the movable die for picking up the blank from said feed table and introducing it into the stationary die, together with means for depressing the feed table and holding it depressed during the working travel of the movable die.



Equipment and Apparatus

Drying refractories or other goods. J. HOLLAND and W. J. GARDNER. *Chem. & Ind.* (London), **42,** 1008(1923).—Improvements in drying refrac. and other goods was subject of a paper read before the Refrac. Mats. Sec., Eng. Ceram Soc., held at

Chester in Oct. This relates to a tunnel drier with traveling racks, with a hot zone 60 ft. long and 3 ft. wide, a longitudinal flue beneath, heated by means of a fur. or by the ht. from waste gases. The flue communicates with two longitudinal lateral flues, one on each side which lead to the chimney stack over the front end of the drier. Continuous with the hot zone is a cooling chamber 10 ft. long. Two parallel steel tracks containing steel rollers extend the whole length from feeding end to delivery end of the drier. As compared with hot-floor drying it is claimed that with this system conditions for workers are better and the goods of higher quality. Much time is saved, and a very much smaller area is required for a given output of silica bricks or other goods. The stove of 2 chambers described can dry 5000 bricks per shift of 9 hrs., using 4 cwt. of coal. O. P. R. O.

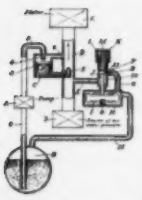
The Proctor drier. A. H. MIDDLETON. *Chem. and Indus.* (London), **42,** 1009 (1923).—The Proctor drier is essentially a close heated chamber, the atm. of which is dry at one end and very humid at the other. The wet goods are thoroughly heated to their core in a very humid atm. before any surface drying can take place. The mach. at Consett is a 3-track tunnel drier consisting of a rectangular chamber 50 ft. long, 20 ft. wide and $6^1/_2$ ft. high, holding cars on each of the 3 tracks, and having a total capacity of 14,976 bricks. If bricks alone were being dried, the drying could be completed in 12 hrs., and probably in 8 hrs. Economical results can be obtained by working the different tracks on different schedules for diff. classes of goods, though of course the best results would attend the drying of one class of goods at a time. Advantages claimed for the Proctor drier, as compared with hot floor, are that drying—especially of difficult shapes—can be carried out much more quickly and with less risk of cracking and setting up drying strains, that the conditions in the molding shop can be made much more healthy and pleasanter for the workers and that a large saving in fuel can be made, excepting when ht. for drying can be provided from exhaust steam or some source that could otherwise be utilized. (Paper read before the Ceramic Soc. of London, Oct. 4.) O. P. R. O.

Metallized electrodes of porous porcelain and the simplest form of the acid alkali cell. K. A. HOFMANN. *Ber.*, **56B,** 1456–63(1923).—Cells have been constructed in which porous porcelain tubes metallized with Pt, Pd, or Ir serve both as a gas electrode and diaphragm. If the metallized porcelain tube is designated as *ptr*, *pdr*, or *irr*, the 2 *N* NaOH as *l*, the 2 *N* H_2SO_4 as *s*, the platinized Pt electrode by *pt*, and the tubes satd. with acid or alkali by *ptrs* and *ptrl*, then the cells' e. m. f.'s are as follows: H_2-*ptrs-l-pt*-H_2, with acid satd. tube dipped in alkali, 0.72 v.; H_2-*ptrl-s-pt*-H_2, with alkali satd. tube dipped in acid, 0.72 v.; O_2-*ptrs-l-pt*-H_2, 1.58 v.; O_2-*pdrs-l-pt*-H_2, 1.55 v.; O_2-*irrs-l-pt*-H_2, 1.74 v.; H_2-*ptrl-s-pt*-O_2, 1.75 v.; H_2-*pdrl-s-pt*-O_2, 1.705 v.; H_2-*irrl-s-pt*-O_2, 1.79 v.; and O_2-*irrl-s-pt*-H_2, 0.32 v. D. MACR. (*C. A.*)

Quartz glass ozonizers. HEBERT FISCHER. *Z. Elektrochem.*, **29,** 318–20(1923).—Under similar standard conditions the O_3 concn. in the quartz ozonizer is considerably less than in a glass ozonizer. The low concn. of O_3 cannot be ascribed to the transparency of quartz to short-wave radiation, for such radiation has not been detected on the outside of the quartz glass ozonizer. Under similar exptl. conditions quartz and glass ozonizers of the same dimensions yield the same O_3 concn. with a Tesla current. Accordingly, the elec. losses in quartz glass have an appreciable influence on the O_3 concn. From this it is concluded that these losses depend largely on the applied frequency. H. J. C. (*C. A.*)

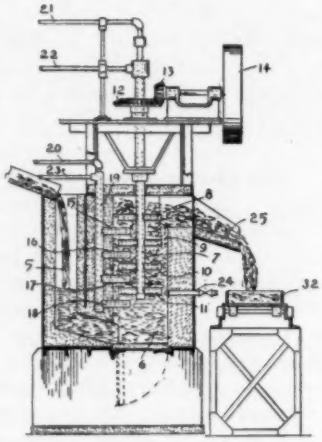
PATENTS

Means to maintain a suitable pressure in the liquid-fuel-storage tanks of airplanes. AUGUSTE CAMILLE EDMOND RATEAU. U. S. 1,471,417, Oct. 23. In a fuel feeding device for a flying mach. propelled by a supercharged motor means to control the press

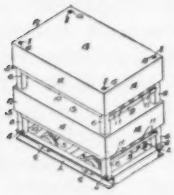


in the fuel tank, which consists in reducing the press. of the air under press. delivered to the motor and applying said reduced press. to the fuel tank.

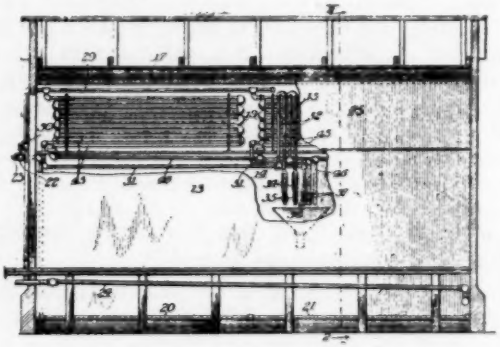
Process of producing porous material. MATHIAS OVROM SEM. U. S. 1,471,421, Oct. 23. The process of producing a porous mat. from molten slag, which comprises continuously leading the molten slag into a container at a temp. of approx. 1400°C, introducing water and a gas therein, subjecting the molten slag and the water to agitation whereby a foam is produced, the introduction of the water being regulated in such manner that the temp. of the foam will be approx. 1000°C, continuously leading the foam into molds and cooling the same to solidification whereby the foam structure is preserved.



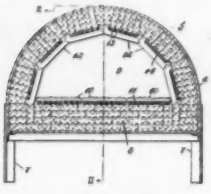
Truck for drying pottery, etc. THOMAS H. RHOADS. U. S. 1,472,676, Oct. 30. The combination of a tray having slats thereon to support the articles to be dried; and a flanged cover extending over the articles and to a point at, or near, the upper surface of the tray, so that heated air, in circulation, will pass up between the slots and the upper portions of the articles will be protected.

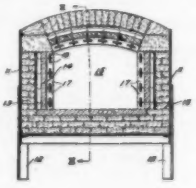


Dry kiln. JOSEPH F. HANRAHAN. U. S. 1,471,602, Oct. 23. In a dry kiln the combination of a drying chamber, a condensing chamber having condensing means therein, heating means and a humidifier, the humidifier arranged between the condensing and heating means, all coöperatively arranged to cause a circulation of air currents from the drying chamber to the condensing chamber, and said humidifier having means for regulating the same.



Electric-resistance furnace. THOMAS A. REID. U. S. 1,472,137, Oct. 30. An elec. fur. comprising a plurality of spaced-apart sets of refractory resistor-supporting plates combined to form substantially self-supporting arches, the plates in each set having interfitting tongue-and-groove edges, and directly supporting an elec. resistor.

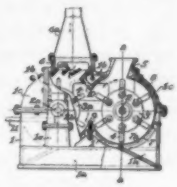




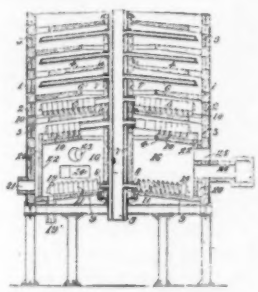
Electric furnace. THOMAS A. REID. U. S. 1,472,139, Oct. 30. In an elec. fur. in combination, a plurality of walls spaced apart to enclose a furnace chamber, a plurality of spaced sets of refractory members of T-shape, having

their narrow ends projecting into said chamber and each having a transversely extending slot in each of 2 opposite faces, and a resistor member extending through said slots and between and beyond said sets of refrac. members.

Pulverizing machine. STANTON C. MARTIN. U. S. 1,472,609, Oct. 30. A pulverizing mach adapted for either fine or coarse work, comprising a double semi-cylindrical casing, parallel rotary hammers in said casing, a mat. inlet pipe leading into one part of the casing, said part having also a discharge outlet, a deflector at the top of the casing between the two parts thereof, and a removable perforated screen over said outlet, through which coarsely pulverized mat. is discharged, the hammers in this case being rotated in opposite directions.



Protecting electrodes passing through fire-brick walls. E. A. A. GROENWALL. Swed. 53,757, Feb. 14, 1923. The electrodes are cooled at those sections that pass through the wall. Extra cooling segments are placed on the wall outside the layer of bricks immediately surrounding the electrodes. (*C. A.*)



Calcining apparatus. ROBERT D. PIKE. U. S. 1,472,935, Nov. 6. A calciner for the described purpose, the same comprising an outer shell, a series of superposed hearths arranged therein in staggered relation, a series of rabble arms associated with and movable over each of said hearths, a rotatable column carrying said arms centrally extended through the shell, a bottom hearth for the shell situated below the lowermost hearth of the series of hearths a distance in excess of the distance between said hearths to provide an enlarged combustion chamber, means for admitting combustible fuel and air for supporting combustion within the said chamber, a series of rabble arms carried by the rotatable column and movable over the bottom hearth of the calciner for advancing calcined mat. to a discharge outlet, and a plow-shaped rabble tooth covering for each of the rabble arms associated with the said bottom hearth.

Kilns, Furnaces, Fuels and Combustion

Surface combustion and its application. W. M. HEPBURN. *Assoc. of Iron and Steel Elec. Engrs.*, **5**, 497-512(1923).—H. discusses the principles of surface combustion and its application to specific furs. The practical utility of combustion involves 3 considerations: (1) the combustion, (2) the furnace, (3) the supply systems. Surface combustion is accomplished by firing an accurate and intimate mixt. of air and gas in a multiplicity of minute intensely hot combustion chambers (under-fired refrac. beds or refrac. diaphragm burners), causing rapid combustion. Such combustion causes large increase in ht. transmission. The desired characteristics of surface combustion equipment are discussed; these include: (1) correct and constant ratio of air and gas; (2) intimate mixing of air and gas; (3) a restricted and definite controlled zone of combustion. Automatic proportioning for maintaining control of the combustion zone is accomplished by the refrac.-bed type and the tunnel type of firing. The intense temp. is obtained in both by localizing the zone of combustion; in the refrac.-bed type the mixt. of gas and air is impinged upon a bed of refrac. granules, and in the tunnel type the zone is localized by sudden expansion in a molded tunnel. The hot surfaces of the granules or tunnels have an accelerating effect on the speed of combustion. In the refrac.-bed type, the burner projects the mixt. into a pocketed bed of refrac., which can be any sub-

stance capable of withstanding temps. over 3400°F, while in the tunnel type, an accurately molded minimum size combustion chamber lined with cement, also capable of withstanding over 3400°F, is used. By minimum size is meant the smallest possible space in which the mixt. capacity of the particular burner can be burned. Examples with figures are given showing the application of these two types to particular furs. The refrac.-bed type has been applied to steel heat-treating furs., and the tunnel-type to pot melting furs. Stacks are used with surface-combustion systems only as passages for flue gases; no draft is required. Pressures required are 1 lb. for producer gas, 8 lbs. for coke-oven gas, and 20 lbs. for natural gas, where compressed gas is used. Some htg. operations are best performed by surface combustion, while others are better carried out by regenerative and recuperative methods. R. J. A.

Oil firing of ceramic kilns. SYMPOSIUM. *Ceramist*, **3**, 77–114(1923).—F. W. WALKER. Average coal consumption for 73 16-ft. downdraft kilns burning wall tile to cone 10 was 12.8 tons of coal; gas consumption for these kilns 360,000 cu. ft. If the coal is considered as having 14,000 B. t. u. per lb. and gas 1000 B. t. u. per cu. ft. and assuming equally efficient combustion conditions, this shows a thermal variation of less than $^1/_2$ of 1%. A smaller updraft kiln 10 ft. 6 in. diameter showed a coal consumption of 8.85 T. as compared with 269,000 cu. ft. natural gas, the thermal consumption being 8.56% greater with gas than with coal. In comparing the consumption of gas with oil when burned in a Dressler tunnel kiln fired to cone 1 over a considerable period and considering the oil as having 142,000 B. t. u. per gallon 20% more oil fuel is used. This agrees closely with the experience of 2 other companies where direct comparisons have been possible. Improvements in designs and operation of furs. will probably reduce this apparent difference. *Comparison of costs:* Assuming the thermal efficiency of these fuels to be the same, a comparison of burning costs including labor, maintenance and sagger breakage charges is made. For this purpose 28,000,000 B. t. u. (the equivalent of one ton of coal of 14,000 B. t. u. per lb.) is taken as a basis of comparison which figure corresponds to 197 gallons of 28 Bé. Penn. oil (thermal value 142,000 B. t. u. per gallon) 28,000 cu. ft. natural gas (thermal value 1000 B. t. u. per cu. ft.). The total costs for one month are given below. Author states costs given for oil are based upon experience of others together with limited personal experience.

	Coal	Gas	Oil
Cost of fuel	$6.05	$12.60	$12.25
Labor cost	2.72	1.04	1.04
Maintenance	1.42	.24	.87
Sagger breakage	2.95	1.22	1.53
Total	$13.14	$15.10	$15.69

Expressed in per cent:

	Coal	Gas	Oil
Fuel	46.2	83.5	78.2
Labor	20.4	6.9	6.6
Maintenance	10.8	1.6	5.5
Sagger breakage	22.6	8.0	9.7
Total	100.0	100.0	100.0

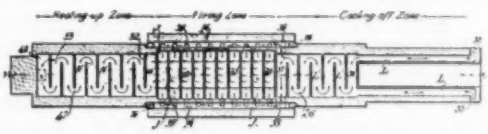
The av. compar. values of the 3 fuels for 25 months are as follows: Oil, $16.59, 129.2%; Gas, $15.25, 118.8%; Coal, $12.84, 100.0%. W. discusses fuel storage, labor and control devices and the effect of these fuels upon the quality of the finished ware. With respect to the latter he is of the opinion that with very few exceptions equal results may be had with each fuel. J. A. WILLIAMS discusses the use of oil fuel in a plant engaged in the manuf. of a white vitrified body burned to cone 12 in one fire. The costs of oil burning equipment are given. A 13-ft. kiln using 6 burners with average burn of about 44 hrs. used about 1760 gals. of oil for each burn. A 14-ft. kiln having a greater height than the kiln previously referred to and having 8 burners uses about 2300 to 2400 gal. of oil per kiln for a burn of about 42 or 44 hrs. duration. Best grade of fuel oil obtainable is used. It has specific

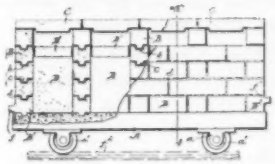
gravity of 36 to 49° Bé. DONALD HAGAR describes the equipment of a low pressure system in use on kilns burning wall and floor tile to cone 10. It has been found that the cost is slightly more to burn bisque kiln with oil than with coal. Also, the data obtained in another plant of the same company shows that oil fuel costs from $15 to $20 less per kiln than natural gas at 45c per 1000 cu. ft The oil used has a thin asphalt base with a specific gravity of 24° to 28° Bé. which is very satisfactory for use in cold weather. R. L. CLARE describes the use of fuel oil in burning terra cotta kilns. The equipment required is stated and theoretical advantages of oil are discussed. No factory data is included. F. N. TUCKER describes the use of fuel oil equipment in a terra cotta plant. No factory data is given. C. W. P.

Growing use of oil fuel in ceramic plants. ANON. *Ceramist*, **3**, 111(1923).—A short list of plants using oil fuel is given and the statement is made that the National Porcelain Works, at Sevres, France, is using oil fuel. This has made possible a reduction of the period of burning from 25 hrs. required for wood fuel to 16 hrs. for oil. It is stated that the oil-fired ovens have given ware of a purer and more uniform color. C. W. P.

PATENTS

Tunnel kiln. LOUIS A. WITTE. U. S. 1,471,875, Oct. 23. A tunnel kiln comprising a continuous lining forming a tunnel chamber and an enclosing masonry structure forming an intervening space divided by transverse partitions, said structure having a central zone with combustion chambers, a heating-up zone with flues for the circulation of combustion gases through such space around the chamber, and a cooling zone with air flues for heating air for combustion purposes by means of the heat transmitted through the walls of the chamber.





Tunnel kiln car. HARRY D. LILLIBRIDGE. U. S. 1,473,152, Nov. 6. In a vehicle of the class described, a load-carrying structure embodying bricks or slabs provided on their meeting faces with mortices and tenons, said bricks or slabs being interlocked and bonded to preclude dislodgment of the bricks under the stresses of the load and upon disintegration, more or less, of the bonding medium.

Geology

Silica in Canada; Its Occurrence, Exploitation and Uses. L. HEBER COLE. Pt. I. Eastern Canada. Canada Dept. of Mines. Ottawa: Government Printing Bureau. 126 pp. (*C. A.*)

Prepared non-metallics (Consumption and possibilities of development). S. J. COOK. *Can. Chem. & Met.*, **7**, 226(1923).—This review gives a summary of an investigation conducted by the Dominion Bur. of Statistics with a view to determining the consumption in Canada of prepared non-metallics. The list of minerals covered was as follows: Actinolite, arsenic, asbestos, barytes, calcite, whiting, chromite, corundum, magnesite, magnesium sulphate, manganese, mica, nitro-alunite, iron oxides, phosphate, pyrites, silica or quartz, sodium sulphate, talc and tripolite. The fields of use covered are as follows: fertilizers, medicinal and pharmaceutical prepns.; explosives, fireworks and matches; paint and soap industries; inks, dyes and colors; polish and dressings, pottery, stoneware, porcelain and enamelware, tanneries, artificial abrasives,

asbestos products, rubber industry, oilcloth and linoleum, roofing and wallpaper. All have detailed tables of statistics and form a very fine report. O. P. R. O.

Physics and Chemistry

Mechanical testing of finished ceramic products. M. GARY. *Sprech.*, **56**, 429–33 (1923).—Methods for testing true sp. gr. and apparent sp. gr. are described. The absorption is detd. by saturating the test pieces under press. with H_2O. Methods for detg. the apparent porosity and true porosity are also described. Laminations are detected by means of a magnifying glass. The degree of vitrification of elec. porcelains are detd. by subjecting test pieces in a soln. of fuchsin in methyl alcohol to a pressure of 15 atms. When subjected to this test the dye should not color the specimen. A water soln. of brilliant green may be used in the place of the extremely poisonous methyl alcohol soln. Special briquettes are described for measuring the tensile strength. Cross-breaking tests are made on 16 mm. by 120 mm. test pieces and the modulus of elasticity is detd. while making this test. For testing the resist. of porcelains to impact the pendulum methods are employed. The compression strength is detd. by means of a hydraulic press. The hardness of ceramic bodies is determined by means of a sand blast. This is allowed to act upon the body 2 mins. and the loss in wt. is used as a means for comparing different wares. H. G. S.

Effect of alkalies on clays and clay products. ANON. *Ceramist*, **3**, 48–55(1923).—A brief résumé of our knowledge regarding the influence of sol. salts upon the amt. of water of plasticity, the working properties of clay, its drying shrinkage, drying behavior, and faults attributable to the presence of sol. sulfates in pottery bodies as well as brick. A gravimetric method for the detn. of sol. salts is given in detail with reference made to the use of an elec. method. C. W. P.

Notes on the crystalline structure of some china clays examined by the X-ray powder method. WILLIAM BRAGG, G. SHEARER AND J. W. MELLOR. *Trans. Ceram. Soc.* (Eng.), **22** [1], 105(1922).—In practice, it is convenient to use a fine slit $^1/_2$ mm. wide and 1 cm. long to define the X-ray pencil. The photographic plate will then show, if it is limited to a strip a little wider than the length of the slit, a series of fine lines, like an optical spectrum, and each such set of lines is unique and belongs to one crystal only, or to an agglomerate of crystals. H. F. S.

Forces of adhesion in solution. II. Coagulation of coarse suspensions. SERGIUS WOSNESSENSKY. *Kolloid-Z.*, **33**, 32–4(1923); cf. *C. A.*, **17**, 1572.—The coagulation by common electrolytes of coarse suspensions of kaolin, $Al(OH)_3$, and Sb_2O_3 was studied. No single electrolytes, with the exceptions of $Ca(OH)_2$ and $Ba(OH)_2$, had any coagulating effect. Marked coagulation occurs with the simultaneous action of bivalent or tervalent metal salts and caustic alkalies, *e. g.*, $BaCl_2$ and NaOH, or $AlCl_3$ and NaOH. These materials form difficultly sol. hydroxides, which are adsorbed on the surface of the particles of the suspension and cause coagulation by changing the forces of adhesion and cohesion. Materials such as NH_4Cl and tartaric acid which hinder the formation of hydroxides disturb the coagulation. The thickness of the absorbed hydroxide is estd. to be of mol. dimensions. C. B. E. (*C. A.*)

Experimental studies of the coagulating powers of electrolyte series. AGNES IVANITZKA AND L. ORLOVA. *Kolloidchem. Beihefte*, **18**, 1–38(1923).—The coagulating powers of several series of electrolytes were studied with the following hydrosols: negative—mastic, sulfosols of As_2S_3 and Sb_2S_3, S, Au, Pt, Berlin blue, MnO_2 and $Fe(OH)_3$ positive—Fe_2O_3, Al_2O_3, Cr_2O_3 and AgBr. In general, the anion series with a const. cation is antivalent for negative sols and convalent for positive sols, whereas the cation series with a constant anion is convalent for negative sols and antivalent for positive sols. Comparative studies of electronegative suspensions of coal in alkaline media

and electropositive suspensions of Fe_2O_3 in acid media were made with true sols and on marked differences were observed in their ability to coagulate by electrolytes. The following substances were added to the dispersion medium of the suspensions to determine their effect on their coagulation by electrolytes: MeOH, AcH, glycerol, Na protalbinate, dextrin and gelatin. Nonelectrolytes affect the stability of the suspensions as well as the rearrangement of the electrolyte series in their coagulating powers. Coagulation is considered to be not simply the result of physical factors, *i. e.*, surface tension, dielec. const., etc., but of relations among all components of the coagulating system, *i. e.*, disperse phase, dispersion medium and electrolytes. I. N. K. (*C. A.*)

The transition in case of mechanical subdivision of crystalline hydrates of the water of hydration into adsorbed water. T. HAGIWARA. *Kolloid Z.*, **32,** 154–6(1923).—$Al_2O_3.3H_2O$ and quartz dried to const. weight were ground in a *colloid mill* and then kept at higher temps. in the desiccator. Weighing showed that at a sufficiently fine state of subdivision of $Al_2O_3.3H_2O$ its water of hydration loosens its firm bond and assumes the properties of adsorbed water. (*C. A.*)

Physical chemistry of the crystalline state. F. KÖRBER. *Z. Elektrochem.*, **29,** 295–301(1923).—An address on X-ray analysis and the study of solids. H. J. C. (*C. A.*)

Fusion, solution and ionization. W. F. SHORT. *N. Zealand J. Sci. Tech.*, **5,** 43–5(1922).—A short discussion in which these phenomena are considered as essentially the same and explained on the basis of radiation hypothesis. A. E. S. (*C. A.*)

Acid borates of sodium. I. F. PONOMAREV. *J. Russ. Phys. Chem. Soc.*, **49** [1], 229–40(1917).—By employing the principle established by Tammann (*C. A.*, **8,** 2971) P. succeeded in prepg. cryst. borates contg. a greater proportion of B_2O_3 than that in borax ($Na_2O.2B_2O_3$). This was accomplished by htg. fused mixts. of borax and anhyd. B_2O_3 in a Pt boat placed horizontally inside of a hard-glass test-tube. The heating being restricted to one end of the boat, a slowly falling temp. gradient was obtained along the fused mass, and the crystn. of the desired borates started at the point possessing the optimum temp., which lay in the middle region between the molten fluid at the heated end and the solid vitreous portion at the cold end. Since at the temp. of formation of the cryst. nuclei the mixt. is extremely viscous and the motion of the crystals very slow, it was possible to measure, with a thermocouple, the limiting temps. of the cryst. formations. Chem. and crystallographic studies were made of mixts. of the oxyborates $Na_2O.3B_2O_3$ and $Na_2O.4B_2O_3$ so obtained. W. A. P. (*C. A.*)

The third principle of thermodynamics and some of its consequences. A quantitative application of Berthelot's principle. VL. A. KISTYAKOVSKII. *J. Russ. Phys. Chem. Soc.*, **53,** I, 247–55(1921).—A quant. formulation of Berthelot's principle of *maximum work* was made which permits of broad applications to the detn. of such quantities as the heat of transformation, the free energy of compds., etc. A restatement of Berthelot's principle is briefly given as: "For every transformation of substances, chem. or phys., a characteristic point may be found by varying the temp. and pressure at which point $A_1 = Q_1$, *i. e.*, the free energy = the heat of transformation, and at the same time $dA/dT = 0$, or, when the 1st deriv. of the free energy to the temp. (the temp. coeff. for the given point) is also = 0." Nernst's theorem presents a special case of the above postulate, namely where $T = 0$. The application of the above principle also leads to the equation $q = T(dA/dT)$, where q is the heat of the side process accompanying the chem. reaction. This leads to the condition in which with small increase in temp. Q becomes either greater or less than A. By using the last equation the temp. coeff. of galvanic elements can be calcd. from the heats of fusion of ice and Hg. It also gives a simple formula for the latent heat of vaporization of poorly associated liquids (cf. following abstr.). The general problem of the max. work which can be obtained from any given reaction is discussed. W. A. P. (*C. A.*)

Latent heat of vaporization. VL. A. KISTYAKOVSKII. *J. Russ. Phys. Chem. Soc.*, **53**, I, 256–64(1921).—A new formula for the calcn. of the heat of vapn. of unassociated liquids was worked out by applying the 3rd principle of thermodynamics (cf. preceding abstr.). The formula is $JQ = RT \ln RT$, which states that for unassociated (or poorly associated) liquids, whose vapors at the b. p. have the normal mol. wt., the heat of vapn. = the vol. of the vapor multiplied by the natural log of the same vol. J is the mech. heat equiv. in joules, Q is in large cals., the gas pressure is in atm. and the vol. in cc. Satisfactorily agreeing values for Q were calcd. by the use of this formula for 74 poorly associated liquids which includes all of those given in Landoldt-Börnstein, *Phys. Chem. Tabellen*, **1912**, 834–42, in addn. to some others of previous Russian data. The new formula does not contain any empirical factors and it is offered by K. as the law of the latent heat of vapn. for unassociated liquids at their b. ps. and at 1 atm. pressure. W. A. P. (*C. A.*)

The behavior of pumice stone during the dehydration of organic liquids. ARMIN SEIDLENBERG. *J. Assoc. Official Agr. Chem.*, **7**, 98–106(1923).—Pumice stone, or any substance consisting of small particles or having numerous fine capillary openings, has a greatly increased tendency to adsorb liquids and gases, particularly after being heated. The wt. of material in this condition is affected to a marked degree by changes in temp. and pressure. It gains wt. after being heated while in a desiccator, and also during the process of weighing. For this reason also it readily adsorbs moisture from the atm. or from liquids spread over it. This adsorbed moisture is held very tenaciously and can only be removed by heating the pumice to redness. It appears that the presence of this adsorbed moisture has a decisive effect in accelerating the decompn. of org. residues distributed over the pumice. When the pumice is heated to redness before being used and all the moisture thus expelled, an approx. const. wt. may at times be obtained due to the balancing effect of 2 opposing errors. This const. wt. may or may not be correct and checks can usually be secured only by prepg. all the pumice used under identical conditions. Where the pumice is dehydrated at the comparatively low temps. used for the evapn. of the liquid it is not possible to secure significant results that will indicate the true amt. of solid matter present. If too low a temp. is used not all the H_2O is expelled, particularly in the presence of viscous material. With higher temps. it is not possible to secure a distinct end-point that will clearly distinguish between the loss due to the decompn. of the solid and that due to the evapn. of the liquid portion, and it is not possible to attain a significant "const. wt." that indicates the correct result.

J. A. K. (*C. A.*)

PATENTS

Mica, asbestos, and like compositions. PLAUSON'S (Patent Co.), LTD. Brit. 193,520, Nov. 29, 1921. Residues of mica, asbestos, talc, and similar silicates are partly or wholly converted into the colloidal state by high-speed mech. disintegration, preferably in a colloid mill as described in 155,836 (*C. A.*, **15**, 1788); the colloidal soln. is subjected to ultrafiltration, dried *in vacuo*, and molded under pressure. Dispersion-accelerators such as colloidal silicic acid, alkali silicates, colloidal ZnO, aluminates, sulfite-cellulose liquor, gum arabic, and tannin may be employed. Fillers or binding agents such as rubber, natural or artificial resins, drying oils, olein, and finely divided clay may be added to the silicate either before or after disintegration. (*C. A.*)

General

Burning wood for heating steam boilers. PIERRE PRÉVOST. *Rev. Mat. Constr. Trav. Pub.*, **168**, 204–5(1923). L. N.

Asbestos industry, S. Africa. ANON. *Mining & Eng. Jour.*, **34**, 465(1923).—

S. Rhodesia has recently become an impt. producer of asbestos, averaging some 12,000 T. annually; further important deposits are being developed in the Transvaal and Natal; also Mozambique. Only 2 or 3 plants in S. Africa make finished products, The raw mat. is first crushed and fiberized, and all foreign elements eliminated without destroying its fibrous qualities. It is then beaten to a pulp and mixed for about 15 min. with Port. cement. If red tiles are to be made, a small quantity of powdered red iron oxide is added. The mixt. is carried by flumes to a mach. which turns out the pulp in large slabs. These are placed in an edge trimming mach. for squaring or cutting into tiles, and thence to an hydraulic press, where the slabs are pressed between steel plates. The finished slabs or tiles are then "cured" by being kept in a drying shed for about 2 months, after which they are ready for a variety of industrial uses. The mach. which converts the pulp into slabs is most interesting in its opern.; one of the rollers picks up the absestos-cement pulp and spreads it layer upon layer on an endless traveling belt. From this it passes to a steel collecting drum; when the pulp is of sufficient thickness a bell rings and the operatives strip it off in the large slabs. Sheets may thus be turned out in varying thicknesses—say from one-eighth to one inch—by increasing or reducing the number of layers of pulp. Millboards made entirely of asbestos fibre are also made, and for this and the asbestos-cement products there is a great variety of uses, apart from bldg. purposes, such as door panels, chair seats, cattle and poultry troughs, road signs, filing cabinets, table-tops, basin and dishes, school blackboards. O. P. R. O

A visit to the potteries of Norway, Sweden and Denmark. DOGAR SINGH. *Trans. Ceram Soc.* (Eng.), **22**[1], 29(1922–23).—"The Porsgrund Pottery Factory" was established in 1885, by the Norwegian Govt. The body mixt. consists mainly of feldspar, quartz, and china clay. The machinery which is used for pugging the body mats. for mfg. hollow ware and flat ware is very economical and scientific. One man and one boy can make 1500 plates in a day. The stove room is also of quite a new type. Each room has 20 compartments and each compartment is divided into 10 shelves, erected on a 4-wheel wagon. When the goods are dried the whole compartment is pulled out and brought to the lift by which it is carried down to the first floor, whence it is taken to the bisque oven. All stoves for drying purposes are on the top floors and utilize the surplus heat given out by the kilns while cooling. Another process, a German patent, is for engraving steel instead of copper plates, for printing purposes. The Rorstrand factory at Stockholm specializes in mfg. porcelain for elec. purposes. These insulating fixtures are made of a mixt. of white-burning clays, feldspars and flint. Articles like wiring fixtures, knobs, cleats, receptacles, attaching plugs, and switchboards are made by the "dust press" method. The presses are very simple, each making from 1500 to 3000 pieces in a day, according to the size of the piece. All these pieces are finished by one firing. Each piece is sent to the testing shop where it is elec. tested. Most of them are tested by a very high tension current of from 2000 to 4000 kw. In Höganas, there is one of the largest concerns for refractory goods in Sweden. This factory also manufactures all sorts of acid jars and sanitary ware. The mats. from which the silica bricks and slabs are made are quartz, sand, fireclay and quartzite. The Bing and Grondahl Porcelain Works are located in Copenhagen. They have charming pieces of statues and cryst. glazes; almost all the figure work has been copied from the Royal Museum from the models of Thorwaldsen's works, the famous Danish sculptor. Here they are making expts. for firing their goods with liquid fuel. They make hotel and ship ware, which are generally sold to Spain, France, England, and South America. The Royal Copenhagen Factory has a special reputation in the pottery world for its under-glaze colors. A few years ago, the factory purchased a new plant for crushing and grinding the raw mats.; this is worked by only two men. This factory has its own special color-mfg. branch, which is run by a skilled and trained man. By the use of pure Norwegian

and Swedish feldspar and quartz, and the finest English china clay, the most charming and attractive goods are manufd., and on them life-like paintings of birds, fishes, animals and water or landscapes, or figure subjects are painted in elegant and admirable underglaze or enamel colors, such as cobalt blue, peacock blue, pink, crimson, greys and greens. Special attention has been given by the Danish factories to the manuf. of saggers. Two pug mills are erected for thoroughly pulverizing and mixing the clay and the grog together. One pug mill is vertical and one is horizontal. H. F. S.

The Danish ceramic industry. CARL JACOBSEN. *Trans. Ceram. Soc.* (Eng.), **22** [1], 20(1922–23).—Boring operations, carried even to the greatest depths at various places all over the country, have yielded evidence of comparatively recent sedimentations only. China clay, high-grade refrac., white burning plastic clay and coal are nowhere to be found in Denmark. Clay suitable for bricks not of very good quality is found in large quantities all over the country. The 200 brick plants of the country produce, in normal times, from 400 to 500 millions annually. In addition to bricks, the brick plants also produce roofing tiles and drain pipes. Bornholm possesses a fairly large deposit of pure china clay. It was formerly used for making china. It is too ferruginous to produce an absolutely white porcelain. Nowadays, it is used for earthenware, in the manuf. of paper, and finally for mixing with fireclay to make refrac., clinkers and saggers. Fireclay of a good, though not of the very best, quality is found in many localities in Bornholm. The Danish common pottery indus. is represented by about forty small works, which turn out both glazed and unglazed ware. Of far greater interest is the artistic ware, with a porous body, which by close coöperation with native artists of distinction, has now attained a high standard. Modern Danish earthenware is produced at the "Alumina" Works, which are associated closely with the Royal Porcelain Works. The concern is now known as the "Copenhagen Fayence Factory." The biscuit ware is fired in a newly erected, continuous, gas-fired Mendheim kiln. A highly important indus. development was initiated by Bing and Grøndahl in the manuf. of tech. porcelain, particularly for elec. purposes. Another concern, the Dansk Porcellanisfabrik, of Kastrup, in Amager, also manuf. electro-technical porcelain. H. F. S.

Kaolin. ANON. *Mining Operations*, 81–2(1922).—Considerable development work was effected, 1922, of the kaolin deposits of Amherst township, P Q.; length of prospecting drifts and cross-cuts totaling 1250 ft.; a large quantity of kaolin, contg. an average of about 50% of white quartz sand has been blocked out. The very ingenious method of mining adopted to bring the crude clay into soln. underground, and to pump this thin pulp from a pump situated in the main drift, to the surface, is really underground hydraulics. The pump installed is a 3-in. two-stage Morris centrifugal sand pump, directly connected to a 60 h. p. elec. motor; the capacity of the pump, at 1200 r. p. m. would be 300 gal. a minute, containing 10% of solid matter. The thin pulp from the pump goes into a settling cone, 8 ft. in diam. in which the coarse sand drops to the bottom and the clay and fine sand in suspension overflows with the water into two sets of troughs each 1000 ft. long, along which the fine sand falls and settles on the bottom, and the jet of water holding the clay goes to eight large settling tanks, the largest of which measures 75 x 72 x 7 ft. After drawing off the top liquid, the settled pulp which now holds 30% china clay, is pumped to the filter-presses under a pressure of 100 lbs. per sq. in. The filter-cakes, which contain about 25% moisture, are placed on racks, and wheeled on cars, into a drying chamber through which circulates a current of hot air. When completely dry, the cakes are broken up and put in the bin, ready for the market. O. P. R. O.

In burning carbon which is formed first, carbon monoxide or carbon dioxide? CARL KULLBERG. *Teknisk Tids.*, **53** (Kemi), 41–6(1923).—Coke was heated in a current of air under proper exptl. control and the CO and CO_2 were detd. Both CO and CO_2

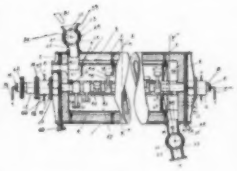
were formed directly from the C and neither one can be considered as primary with respect to the other. The relative amts. depend upon the temp. With an increase in the temp there was a relative increase in the CO_2. For 360° the figures reported indicate that there was 1 part CO to 4 parts CO_2. The burning of the CO to CO_2 is a relatively slow reaction and in the course of the expt. (360° series) only about 10% of the CO formed was oxidized. This work is in reply to the theories of Aufhäuser at present debated in the German journals. (Cf. book reference under A. in *C. A.*, **16,** 1311.)

A. R. R. (*C. A.*)

Research, an industrial investment. H. E. Howe. *J. Am. Leather Chem. Assoc.*, **18,** 465–75(1923).—A plea for research in fundamentals. Instances are cited of the great rewards attending persistent research. J. A. W. (*C. A.*)

PATENTS

Retort for the distillation of shale, bituminous coal, and other materials. Claude M. Garland. U. S. 1,473,616, Nov. 13. In a device of the character described, a substantially horizontally arranged cylindrical retort, a charging device located near one end of the said retort, a discharging device located near the opposite end of the said retort, a false head near the discharge end of the said retort, an aperture for the discharge of material located in the said false head and a gate for varying the opening of the said aperture.



Pottery, bricks, etc. M. Bacchiolelli and A. Meifree-Devals. Brit. 196,342, Jan. 14, 1922. Igneous rocks such as lava, basalt, dolerite, greenstone, etc., for use in pottery and making brick and tile, are crushed to powder and agglomerated under the influence of heat (with or without the addn. of impoverishing substances such as chamotte, quartzite, sand, etc., or fluxes) at a temp. lower than their own m. ps. The rock may be crushed to powder and porphyrized and if desired mixed with impoverishing materials and H_2O added to form a paste. It is then shaped by any known process either in the mold with or without pressure or in the lathe or by pouring in the state of slip in an absorbing mold. After being finally fashioned, it is dried and fired at the required temp. Other processes are stated. (*C. A.*)

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EDITORIALS

WHAT OF 1924?

The twenty-fifth year of service is now history. The mistakes and shortcomings cannot be retrieved. The things accomplished will continue always as benefits to ceramic industries. There is only one sane resolution of purpose for the new year; each officer, committeeman and member will do his share in achieving more in 1924 than has been achieved in any previous year.

The 1923 conventions of the SOCIETY were the most largely attended and of the greatest value. Those of 1924 will exceed those of 1923. The Committees accomplished more in 1923 than in any previous year and they are set for even greater productiveness in 1924. The 1923 *Journal* of original research reports was more voluminous and equal in quality to any previously published and the *Journal* for 1924 promises to be equal to if not surpassing that of 1923.

The abstracts of the world's ceramic literature was progressed in 1923 in quality and scope but the plans for 1924 have been perfected in detail for even more thorough and better abstracting.

The SOCIETY will accomplish in 1924 just what the members shall will it to accomplish. There is no one person nor any group of persons elected or self-appointed who can have an enduring reason or a continued opportunity to make of the SOCIETY anything other than what is profitable to the

majority of the members. The prospects for 1924 are indeed very promising in increased value of services rendered by the SOCIETY.

THE BIG IDEA OF THE AMERICAN CERAMIC SOCIETY

1. The AMERICAN CERAMIC SOCIETY was founded twenty-six years ago by a group of ceramic manufacturers and educators to promote the ceramic arts and sciences. It was chartered under the laws of Ohio as a non-profit sharing corporation for this announced purpose and has continued as such for these twenty-six years.

2. Six years ago it reorganized its procedure by establishing Industrial Divisions and Local Sections, and changing its publication from annual *Transactions* to a monthly *Journal*, and establishing standing committees for Research, Standards, Data, Geological Surveys and Education.

3. The Divisions and Local Sections are self-governing groups each with their own officers and committees. Each Division holds four technical sessions at the Annual Convention thus making these conventions really seven conventions in one.

4. The method of promoting the ceramic arts and science is by (*a*) conventions, (*b*) publications of research reports, (*c*) abstracting of the world's literature, (*d*) preparation of bibliographies, (*e*) assisting research laboratories in the finding of problems, the securing of materials and analyzing the results and (*f*) promoting coöperative research and ceramic educational enterprises.

5. The SOCIETY promotes the making of research contacts by trade associations with established laboratories, and develops collaborations of private industrial laboratories.

6. It organizes research groups of manufacturing concerns for the benefit of the supporting firm members.

7. It carried through the campaigns that resulted in the establishing of ceramic departments in the Federal Bureaus and has promoted the establishing of collegiate ceramic schools.

8. These several activities may be summarized into the one "Big Idea of the Society," that of a strong promoting, reporting and recording research and educational organization of ceramic manufacturers in which all have a common interest and equal rights and benefits.

9. It does not encroach upon nor conflict in purpose with any activity which any trade association or publication has or could undertake. In fact, the constant endeavor is to collaborate with these trade organizations. It does not finance researches, maintain laboratories nor conduct courses of ceramic education. It does not maintain its *Journal* for financial profit.

10. It is said, and we believe truly so, that the conventions and publications of the AMERICAN CERAMIC SOCIETY have been more productive and most effective agents for the dissemination of knowledge of ceramic technology and science. The SOCIETY has been constant in its advocacy of research and technical plant control until today there is a very general appreciation of the value of these as shown by the coöperative researches conducted by trade associations and by the demand in excess of the supply for trained ceramic engineers.

11. We submit that there is an economic value in all industrial ceramic groups supporting this SOCIETY both on account of the many problems that are of common concern and because of the importance of maintaining the strongest possible research promoting and publishing organization devoted altogether to the promotion of the ceramic arts and sciences. The AMERICAN CERAMIC SOCIETY is not commercial either in purpose or procedure. All of its income is spent in service. It is not controlled by any limited interest but is managed by a board of eleven, nominated and elected by its supporting members. Everything possible must be done to meet the expectations of the 1962 persons and 290 corporations who are now supporting the SOCIETY. It is for this reason we are seeking the confidence, support and collaboration of all ceramic persons, concerns and associations.

If you believe that a strong organization of this sort and for the purposes stated is of value you are urged to participate in the work and to invite others to share in its support and in the benefits which accrue.

ACTIVITIES OF THE SOCIETY

THE PRESIDENT'S PAGE

Our Membership Growth

By A. F. Greaves-Walker

There has been no doubting of the value of having one strong and active association such as is the American Ceramic Society, common to all ceramic interests for the exclusive purpose of promoting the technical, scientific and artistic welfare of the ceramic industries.

There has been no questioning of the honor, rights and benefits of membership in such an organization governed as this Society is for, by and of the members.

There has, however, been a questioning of the value of broadcasting the privileges of membership to all ceramic workers. It would be futile to argue the case for it is a demonstrated fact that the more generally peoples are informed the higher will be the plane of excellency in production and the greater will be the returns to all, both materially and in personal comfort and satisfaction. This is true in social and political life. The country in which the opportunities for education and the means of pleasure and comfort are the most generally enjoyed is the most progressive and is the most substantial. This is true in all human activities. It is true in ceramics.

It is sound in practice and in theory for each ceramic group to maintain separate trade organizations. Each has its own peculiar labor and trade problems.

It is practical and certainly most effective in promotion of the technical welfare of each group and of ceramics in general that each trade association engage in coöperative research of their production problems. There is value accruing directly to each trade association group and indirectly to ceramic industries generally in operative institutes and vocational schools. It has been demonstrated that the industries can in these ways do more to produce better ware at lower cost and be more able to keep abreast with competition and quality demands.

The direct returns from technical research and education is an experienced reality. It does not admit of argument and there is no need of demonstration. There is, however, the necessity of bringing each manufacturer to an actuating appreciation of the returns which surely will follow from technical research and education.

We often forget that there would be no amount of technical advance made and very little education had if there were no revealing record made of observations and experiences so that the ideas and findings of each can be tried by several under different conditions and for different purposes until the fundamental principles have been found and demonstrated. The Universities cannot create all the knowledge. They can merely do their bit along with others as a side line to their principal business of training men educationally. It is from records of industrial application that most knowledge is obtained.

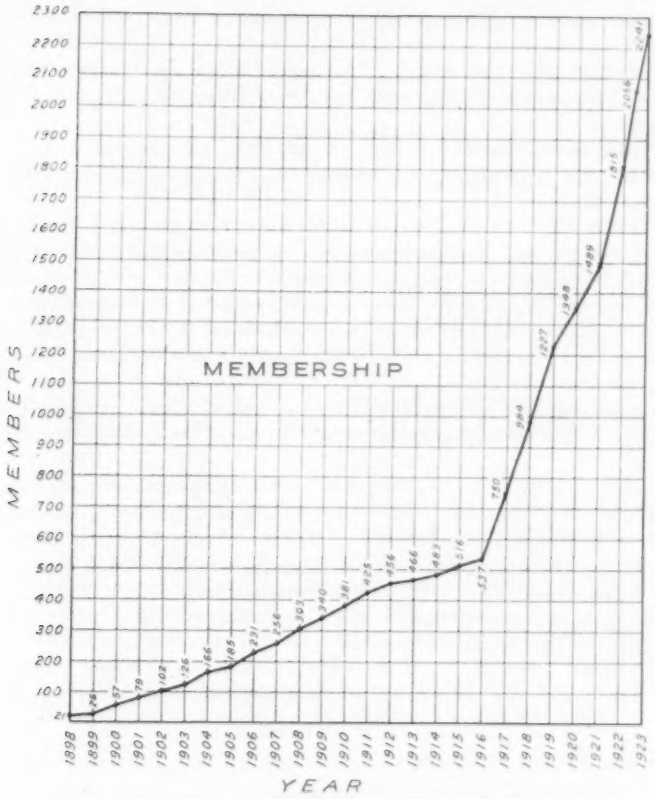
It should be very apparent that it is important to progress of industrial ceramics that there be a common pooling agency for all the ceramic groups such as the American Ceramic Society through and by which knowledge is recorded, abstracted and indexed; and by and through which the several groups contribute their share to the general record of facts and principles. There is an inestimable value to each ceramic concern to have the world's literature abstracted and made available. There is a direct value in committees gathering proved data and finding means of contact with and giving assistance to research agencies in the finding of new facts of immediate importance.

With so much in common technically, there is direct value in all the ceramic groups giving adequate support to a common agency devoted exclusively to the promotional

activities. And it is equally important that the educational benefits of participation in the obtaining and recording of ceramic knowledge shall be extended to every employee and employer who has the capacity and the desire to use knowledge.

The ceramic fraternity generally takes pride and has reason for satisfaction in the growing appreciation of the value of technical research and education and of the need of having a strong organization through which the knowledge from world-wide sources are collected and made known. This growing appreciation is shown by the rapidly growing roster of the AMERICAN CERAMIC SOCIETY.

ARE WE GOING OVER THE TOP?



New Members Received from Nov. 16–Dec. 15

PERSONAL

Robert Burhans, Jr., 607 Pacific Finance Bldg., Los Angeles, Calif., President and Genl. Mgr., Feather-Stone Insulation Co.

Robert R. Busbey, Canton, Ohio, Sales Engineer, The Robinson Clay Product Co., Akron, Ohio.

A. J. Des Lauriers, 311 Chestnut St., St. Paul, Minn., Manufacturer of Milk Cans.

Edwin Burk Estabrook, 4901 Stenton Ave., Philadelphia, Pa., Sales Engineer, Leeds & Northrup Co., Philadelphia, Pa.

Harold Feichter, 209 W. 8th St., Parkersburg, W. Va., with U. S. Roofing Tile Co., Parkersburg, W. Va.

C. Walther Fernholtz, 2053 E. 38th St., Los Angeles, Calif.

Thomas Graham, Box 938, Medicine Hat, Alberta, Canada, Supt., Alberta Clay Products Co., Ltd.

Joseph C. Hearn, President, Saks Stamping Co., Huntington, W. Va.

W. G. Jackson, 258 South Alexandria Ave., Los Angeles, Calif., Manager, Empire China Co., Burbank, Calif.

William G. Jackson, Jr., 258 South Alexandria Ave., Los Angeles, Calif., Empire China Co., Burbank, Calif.

Richard D. Leitch, Asst. Chem. Engr., U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

James H. McCabe, 1758 Central Ave., Cincinnati, O., McCabe Construction Co.

Clarence B. McComas, 1226 Belmont Ave., Baltimore, Md., Chemist, Carr-Lowrey Glass Co.

Wm. E. Magill, Buckwater Stove Co., Royersford, Pa., Mgr., Enamel Dept.

Carl Mehling, 2248 Elmwood Ave., Buffalo, N. Y., Manager, Enamel Department, American Radiator Co.

James G. Moore, 701 Vernon Ave., Long Island City, N. Y., Manager, Peerless Glass Co.

Douglas E. Parsons, 1824 New Hampshire Ave., Washington, D. C., Associate Engineer, Ceramic Division, U. S. Bureau of Standards.

William Pettigrew, 728 Main St., Worcester, Mass., Assistant, Microscopical Division, Research Laboratory, Norton Co., Worcester, Mass.

Frank Piatt, 1495 Franklin Ave., Apt. C, Columbus, Ohio, Salesman, Louisville Fire Brick Works, Louisville, Ky.

Fred Redmond, Pacific Clay Products, Inc., Los Angeles, Calif.

Wm. A. Roffe, Pacific Beach, San Diego, Calif., Secy. and Treas., San Diego Tile & Brick Co.

Olive F. Shults, Alfred, N. Y., Student at State School of Ceramics.

M. A. Snell, 220 Wisconsin Ave., Oak Park, Ill., Chemical Engineer, Ceramics Division, Western Electric Co., Chicago, Ill.

Norman Stein, Bonnybridge, Scotland, Director, John G. Stein & Co., Ltd.

Chas. H. Taylor, McCall, Ky., Mfr. of fire brick and refractories.

Herbert K. Turk, Porcelain Enamel & Mfg. Co., Baltimore, Md.

G. B. Tuthill, 131 West 63 St., Chicago, Ill.

John H. Voorhies, Alfred, N. Y., Student at State School of Ceramics.

Henry Weiss, West Coast Porcelain Mfrs., Millbrae, Calif.

CORPORATION

The Baltimore Enamel & Novelty Co., P. O. Box No. E-4, Baltimore, Md., Porcelain Enamel Signs, H. B. Little, Vice-president.

The Crossley Machine Co., Trenton, N. J., Machinery Manufacturers, Donald M. Miller, Sec'y.

Locke Insulator Corp., Maryland Trust Bldg., Baltimore, Md., Porcelain Insulators, F. H. Reagan.

Montgomery Porcelain Products Co., Franklin, Ohio, Mfrs. of Pyrometer Protection Tubes, E. T. Montgomery, Member of Firm and General Manager.

Southern California Gas Co., 950 South Broadway, Los Angeles, Calif., Lee Holtz.

The Robinson Clay Product Co., 1100 Second National Bldg., Akron, Ohio. Manufacturers of Sewer Pipe and Fire Brick, H. B. Manton, Pres.

Membership Workers' Record

	Personal	Corporation		Personal	Corporation
C. E. Bales	2		E. T. Montgomery		1
A. W. Crownover	1		F. B. Ortman	1	
R. R. Danielson	1		W. G. Owen	1	
Howells Frechette	1		William E. Rice	1	
C. E. Fulton	1		John Sawyer	4	
R. F. Geller	1		Alan Stein	1	
Arthur F. Gorton	1		Homer F. Staley		1
R. K. Hursh	1		Karl Turk	2	
A. A. Klein	1		Edward J. Vachuska	2	
T. G. McDougal		1	Office	7	2
C. R. Minton		1		—	—
			Total	29	6

PERSONAL NOTES OF MEMBERS

E. E. Ayars, Chairman of the Refractories Division, is living at 11020 Detroit Ave., Cleveland, Ohio.

Wilbur F. Brown, formerly of New York has been transferred by the Libbey-Owens Glass Company to Nicholas Bldg., Toledo, Ohio.

J. L. Crawford, who has been Research Assistant, Mellon Institute, Pittsburgh, Pa., has accepted a position with the Laclede-Christy Clay Products Co., Railway Exchange Bldg., St. Louis, Mo.

J. C. DeKort is living at 951 Main St., Wheeling, W. Va.

W. E. Dornbach has moved from Baltimore, Md. to 929 Marlyn Road, Philadelphia, Pa.

William H. Lucktenberg has notified the Secretary's office that he has moved from Zanesville, Ohio to 445 S. Ohio Ave., Columbus, Ohio.

George J. Openhym asks that his address be changed from Scarsdale, N. Y. to 80 Walworth Ave., White Plains, N. Y.

F. A. H. Schepers of the Advance Terra Cotta Company has moved from Chicago Heights to Crystal Lake, Ill.

V. S. Schory has moved from 231 Hudson St., Tiffin, Ohio to 914 W. Walnut St., Kokomo, Ind.

Frank C. Schultz, student member has moved to 231 16th Ave., Columbus, Ohio.

Arthur R. Stanbra has notified the Secretary's office that he has moved to 951 Main St., Wheeling, W. Va.

W. J. Sutton, who has been Assistant in the University of Pittsburgh has moved to Foochow, Fukien Province, China., Fukien Christian University.

George A. Williams of Tottenville, Staten Island, N. Y., has accepted a position with Wunderlich Ltd., Sydney, Australia.

Warren S. Williams, formerly of Arnold, Pa., is now living at 815 E. Harvard St., Glendale, Calif.

Wm. A. Yung of the MacBeth-Evans Glass Company has been transferred from Pittsburgh to the Charleroi office of the Company.

NEW LOCAL SECTIONS ORGANIZED

University of Washington Student Local Section

The Board of Trustees of the AMERICAN CERAMIC SOCIETY has granted a petition for the formation of a Local Section of the SOCIETY to be known as the University of Washington Student Section of the AMERICAN CERAMIC SOCIETY. The officers elected are M. E. Reynolds, Chairman and Wallace Thoreson, Secretary. Paul S. MacMichael and Hewitt Wilson were instrumental in the organization of the Section. Monthly meetings will be held throughout the year. Those signing the petition for a Charter were Winthrop C. Brown, Hobert R. Goodrich, Hilding E. Johnson, M. E. Reynolds, Wallace Thoreson, Fred W. Schroeder, Henry C. Fisher, Thomas J. Etherington, Thad. O. Smith, Ralph L. Smith.

Pacific Northwest Section

A second petition has been received by the Board of Trustees of the SOCIETY asking that a charter be granted to a new Section, to be known as the Pacific Northwest Section of the AMERICAN CERAMIC SOCIETY. The organization was effected at a meeting of the Pacific Northwest Clayworkers' Association held on December 8. The Section was formed to take care of all matters dealing with relations between the AMERICAN CERAMIC SOCIETY and the Pacific Northwest Clayworkers' Association.

The officers chosen for the Section are Paul S. MacMichael, President, and Hewitt Wilson, Secretary. S. Geijsbeek was elected Councilor until the January meeting. An invitation has been extended to the members of the SOCIETY to visit the Pacific Northwest on the Summer Meeting tour for 1924.

The following members signed the petition asking for the charter: Paul S. Mac Michael, S. Geijsbeek, H. Wilson, F. T. Houlahan, R. A. Swain, M. L. Bryan, Charles P. Oudin, Ernest F. Goodner, W. E. Lemley, A. Lee Bennett, A. H. Wethey, Jr., and L. A. Martin.

Baltimore-Washington Section Petitions

On December 14, 1923, the organization of the Baltimore-Washington Section of the AMERICAN CERAMIC SOCIETY was held at the Garden Tea House, Washington, D. C. Thirty-eight were present and the following officers were elected.

B. T. Sweely, Chairman
Karl Turk, Councilor
R. R. Danielson, Vice-chairman
Secretary-Treasurer, Herbert Insley

A motion was passed that the AMERICAN CERAMIC SOCIETY be petitioned for permission to form a local section and that dues of $1 a year would be asked to carry on the work of the Section. Members will also be admitted who are not members of the AMERICAN CERAMIC SOCIETY.

The meeting was concluded by a short paper by Herbert Insley on the uses of the petrographic microscope in the ceramic industry.

Those attending the meeting were:

Stephen Leech, B. T. Sweely, Joseph P. Rodgers, Karl Turk, Hebert Turk, Richard Turk, Albert Krekel, Edgar A. Worsham, B. W. Ellis, C. B. McComas, C. A. Barrett, Reardon Fusselbaugh, H. B. Little, R. M. Balmert, A. C. Cameron, F. W. Owens, W. B. Taylor, R. R. Danielson, H. D. Foster, Karl Langenbeck, W. L. Prendergast, M. L. Walters, T. D. Hartshorn, A. N. Finn, W. N. Harrison, H. L. Gaardsmoe, V. J.

Roehm, P. H. Bates, D. C. Lindsay, D. E. Parsons, R. F. Geller, E. W. Washburn, Louis Navias, H. G. Wolfram, W. J. Scott, H. Insley.

Fall Meeting of the Pittsburgh Section

H. G. SCHURECHT

A dinner was served at the University Cafeteria and in spite of the bad weather about forty attended. After the dinner, and before going over to Mellon Institute, R. C. Purdy gave a short informal talk on the growth and development of the SOCIETY. Following this the regular meeting was held at the Mellon Institute. The meeting was called to order by Professor A. Silverman.

Professor Silverman proceeded to introduce Frederick Carder of the Steuben Factory, Corning Glass Works, an authority on colored and art glass. Mr. Carder gave an interesting illustrated talk on the development and technique of the glass industry starting with ancient practice and leading up to that of modern times. He concluded his talk by exhibiting some beautiful specimens of modern art glass.

The next speaker introduced by the chairman was Jameson Handy of the Picture Service Corporation of Chicago. His talk was on the value and application of animated and "slow moving pictures" to modern science and how the camera can detect and show things that the eye cannot perceive. He illustrated this by showing a series of three reels of pictures ending with an animated cartoon picture.

A rising vote of thanks was then extended to Mr. Carder and Mr. Handy, and the meeting adjourned.

Those attending:[1]

C. G. Dunkle,—H. J. Heinz Co.
Chas. R. Fettke,—Carnegie Tech.
C. J. Huot,—Pittsburgh Lamp Brass & Glass Co., Swissvale, Pa.
F. C. Flint,—Hazel-Atlas Glass Co.
W. F. Wenning,—Vitro Mfg. Co.
C. R. Peregrine,—% Macbeth Evans Glass Co.
Donald W. Ross,—Findlay Clay Pot Co., Wash., Pa.
Theo. Lenchner,—Vitro Mfg. Co.
John F. Laudig,—H. J. Heinz Co.
K. T. Cheong.
Rudyard Porter.
A. Silverman,—Univ. of Pittsburgh.
H. W. Webber,—Vitro Mfg Co.
Dr. E. W. Tillotson,—Mellon Institute.
T. W. Garve,—Findlay Clay Pot Co., Wash., Pa.
Dr. C. J. Engelder,—Univ. of Pittsburgh.
W. A. Carter,—Burrell Technical Supply Co.
M. L. Bell,—Carnegie Steel Co.
F. Robertson,—Mellon Institute.
C. E. Skinner,—Westinghouse Electric Co., East Pittsburgh.
G. Pole,—Mellon Institute.
K. F. Stahl.
F. F. Rupert,—Mellon Institute.
T. J. Volkommer,—Vitro. Mfg. Co.
R. W. Henry,—Mellon Institute.
L. H. Miller,—Carnegie Institute.

[1] Members are from Pittsburgh unless specified otherwise.

W. C. Fernow,—Aluminum Company of America.
Wm. A. Yung,—Macbeth-Evans Glass Co.
O. P. Brysch,—Koppers Co. Labs., Mellon Institute.
Harold J. Rose,—Koppers Co. Labs., Mellon Institute.
O. O. Malleis,—Koppers Co. Labs., Mellon Institute.
Roy E. Swain.
A. C. Bakken,—Aluminum Company of America.
W. N. Stoneman.
C. S. Taylor,—Research Bureau, Aluminum Company of America.
C. A. Styer,—Westinghouse Electric Co., East Pittsburgh, Pa.
C. M. Bouton,—Bureau of Mines.
H. H. Blau,—Macbeth-Evans Glass Co.
K. K. Stevens,—Carnegie Tech.
D. O. Evans.
S. S. Cole, Koppers Co. Labs., Mellon Institute.
F. Merian.
C. A. Stone,—Macbeth-Evans Glass Co.
C. H. West,—Westmoreland Specialty Co., Grapeville, Pa.
S. B. West, Westmoreland Specialty Co., Grapeville, Pa.
A. E. Blake,—The U. G. I. Contracting Co.
R. C. Purdy,—General Secretary, AMERICAN CERAMIC SOCIETY, Columbus, Ohio.
J. E. Hansen,—Mellon Institute.
R. E. Arnold.
T. H. Sant,—John Sant & Sons Co., East Liverpool, Ohio.
C. J. Rodman,—Westinghouse Electric Co, East Pittsburgh, Pa.

1924 ANNUAL CONVENTION

Atlantic City in February is delightful. None of the hotels would consider a convention between February 15 and April 1, because of the regular patrons who during this period crowd Atlantic City. It was necessary to set the convention ahead to the week of February 4 to get it scheduled in Atlantic City. The weather is fine, the salt water bathing is fine, and the board walk and piers are going full tilt all during February.

So much for the season.

The place needs no advertising; it is the greatest resort in America, winter or summer. So much for the place.

Those who attended the last two annual conventions of the AMERICAN CERAMIC SOCIETY know that there will be people there to meet, papers to hear, discussions to participate in, and buttonhole lobby chats which none can afford to miss. The general sessions on Monday will be of great interest and value to all. The Division Sessions on Tuesday and Wednesday will pound brass tacks into your problems. Each industrial group will meet separately, with the programs for each confined to their specific and special problems.

The occasion, by record established and by program assured, will be most profitable.

The hosts—can there be a more promising forecast of a well organized, comfortable stay in Atlantic City than to say that the New Jersey Clay Workers Association and Eastern Section of the AMERICAN CERAMIC SOCIETY will be the hosts?

This is the set-up for a dignified and profitable convention in America's greatest playground at a popular time of the year for a sea-shore vacation.

SOME OF THE 1923 WORKERS[1]

In the good old days when the entire membership could sit around a table in Section Q with open notebooks and with open frank minds and when each one was known and hailed by his first name, there was a fellowship, a "bond that ties" which counted for loyalty to the group and to each other.

Today there are several such group meetings together and the development and showing of that same fellowship and loyalty which distinguished that single group twenty to twenty-six years ago. There is today more extensive and intensive fellowship among ceramists. This does not need cultivating; it is flourishing because of its realized value to the individuals, to the SOCIETY and to industrial ceramics in general.

It is impossible, however, for any person, even the General Secretary, to know all the members. There is need of making more generally known the faces and the history of the individuals. A complete album, as is had by many organizations, would be very valuable and the SOCIETY will some day be in position to compile and publish one. It is an anticipation of this that the workers will from time to time be shown in the *Journal*.

Robert J. Anderson

R. J. ANDERSON

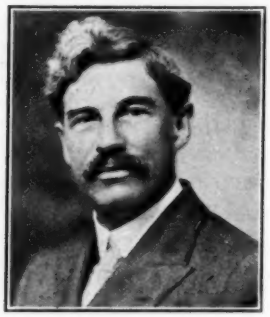
Born in Cleveland, Ohio, 1892. Attended Case School of Applied Science, 1910–1914, B.S. in metallurgy, 1914. Elected to all honorary, scientific, and scholarship societies in undergraduate school (Theta Tau, Tau Beta Pi, Sigma Xi); post graduate degree Metallurgical Engineer, Case School 1917. Successively instructor in metallurgy, University of Missouri, School of Mines, Rollo, Missouri; metallurgical engineer, American Rolling Mill Co., Middletown, Ohio; research metallurgist with Henry Howe, Columbia University; engineering editor of *The Iron Trade Review*, Cleveland, Ohio; chief metallurgist Cleveland Metal Products Co.; aeronautical engineer, Bureau of Aircraft Production, Detroit; consulting metallurgist; now metallurgical engineer, chief of non-ferrous metals section, U. S. Bureau of Mines, Pittsburgh. Pioneer investigator in U. S. in metallurgy of aluminum. Wide contributor to technical and scientific press on metallurgy. Author, "Metallurgy of Aluminum and Aluminum Alloys," in press 1923–1924. (Henry Carey Baird Co., New York, N. Y.) Became member of this SOCIETY, 1923. Member, A. I. M. M. E. A. S.

[1] The likenesses and personal histories here given do not include all of the 1923 workers. The photo and sketch of several of them have already been given in earlier issues of the *Journal*. Some are not here through inadvertant oversight of the Editors. Others are adverse to having their pictures and sketches given.

It is not possible at this time to present a complete album of the workers. It is planned to continue collecting photos and personal histories until the SOCIETY shall have its records complete.

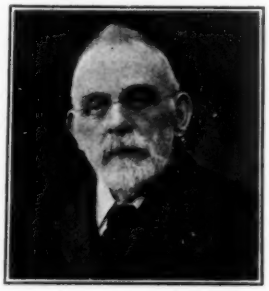
T. M.; Institute of Metals (England); Franklin Institute; S. P. E. E.; A. A. A. S.; American Foundrymen's Association; etc. Contribution to *Journal*, 1923, "Metallurgical requirements of refractories."

George H. Ashley



G. H. ASHLEY

Born 1866, Rochester, New York; graduated 1889 with degree of M.E., Cornell University; 1889–1891, with Ward's Natural History Establishment, Rochester; 1891–1894, assistant, Arkansas Geological Survey; 1892–94, post-graduate student Stanford University, degree of A.M. in 1892, Ph.D. in 1894; 1894–1896, teacher of geology, physics, and chemistry in High Schools of Stockton and San Bernardino, California; 1896–1900, assistant state geologist of Indiana and part time acting state geologist, in charge of survey of coal lands of that state; 1900–1903, professor of biology and geology in College of Charleston, S. C.; at the same time assistant of the U. S. Geological Survey; 1903–1910, assistant geologist and, later, geologist of the U. S. Geological Survey and Chief of Section of Eastern Fuels of all geological work in the eastern coal fields, including coöperative work in Pennsylvania; 1910–1912, state geologist of Tennessee; 1912–1919, geologist, U. S. Geological Survey and part time administrative geologist and acting director. Chief of the Section of Eastern Coal Fields. Chief of the Section on Coal of the Land Classification Board; 1919, state geologist of Pennsylvania. Contribution to *Journal*, 1923, "The fire brick materials of Pennsylvania."



J. A. AUDLEY

James Aloysius Audley

Born 1858, Liverpool, England. Raised in the potteries district of North Staffordshire. Attended evening science classes at the Wedgewood Institute Potteries, Mechanics' Institution, and Minton Memorial Building. Studied as a science teacher in training at the Royal College of Science, 1880–1884. Obtained associateship in geology and biology. Elected fellow of Institute of Chemistry of Great Britain and Ireland and a fellow of the Chemical Society of London. Was graduated 1893 with B.S. degree from London University. Served as Science Master at Hanley for sixteen years, two years organizing and teaching science at Shrewsbury Technical School. Became technical chemist at the Eastwood Sanitary Works, Hanley, 1904–1913. Since 1914 connected with and now director of the New Hall Works Pottery Co., Ltd. Contribution to *Journal*, 1923, "The Ceramic Society (English)."

A. E. BADGER

Alfred E. Badger

Born in Cleveland, Ohio, November 25, 1899. Attended Case School of Applied Science 1918–1922.

Associate physicist, glass technology department of National Glass Works in 1922. Joint author with C. D. Spencer of article in *Journal*, 1923, "A skiagraphic study of fabricated glass articles."

Arthur E. Baggs

A. E. BAGGS

Born in Alfred, N. Y., 1886. Ceramic training at New York State School of Ceramics, Alfred, N. Y. 1903–1905 and 1909–1911. Appointed instructor in pottery, Marblehead Handcraft Shops, Marblehead, Mass., 1905. Director of Marblehead Potteries since 1905 and owner since 1915. From 1912–1918 had further study in New York City and served as part time instructor at the Ethical Culture School. Became member of the AMERICAN CERAMIC SOCIETY, 1910. Member Master Craftsman, Boston Society of Arts and Crafts; New York Society of Craftsmen. Chairman, New England Local Section, this SOCIETY, 1923.

Cecil Eugene Bales

C. E. BALES

Born in Livingston, Kentucky. Attended public schools in Louisville. Graduated Du Pont Manual Training High School and Branch School of Engineering. College training secured at University of Chicago and University of Kentucky. Chief chemist, Louisville Fire Brick Works and field assistant of Kentucky Geological Survey. Became member of this SOCIETY in 1921, active member, 1923. Member American Chemical Society, Ceramic Society (English) and Kentucky Academy of Science. Chairman of Program Committee, Refractories Division this SOCIETY, 1923.

Frederick E. Bausch

Born in St. Louis, 1871. Graduated from Washington University in 1892 with degree of electrical engineer. Taught three years at St. Louis Manual Training School, 1892–1895. Attended Cornell University, 1895–1896. Electrical engineer with Bell Telephone Co. of Missouri. 1898–1900, mechanical engineer, Missouri Edison Electric Company. 1900–1901, chief engineer, Crystal City, Missouri, plant of Pittsburgh Plate Glass Co. 1901–1923, manager, St. Louis Territory, Hooven, Owens, Rentschler Company of Hamilton, Ohio. Also proprietor of Frederick E. Bausch Fire Clay Mines in St. Louis county and crucible clay mines, Kaolin, Illinois, 1903–1923. Chairman, St. Louis Section, this SOCIETY, 1923 Became member this SOCIETY, 1919; active member, 1923.

F. E. BAUSCH

Marcus L. Bell

Was graduated from the New York State School of Clay Working and Ceramics at Alfred, New York.

M. L. BELL

Now ceramist with the Carnegie Steel Company, Pittsburgh, Pa. Became member of the AMERICAN CERAMIC SOCIETY in 1909, active member in 1919. Chairman of the Committee on Research, Refractories Division, this SOCIETY, 1923.

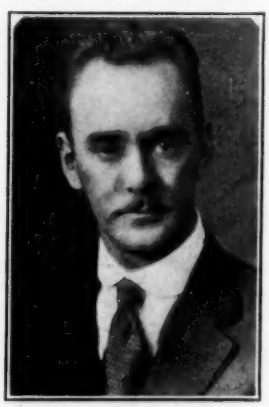
A. E. Blake

Born Nashua, New Hampshire, 1887. Was graduated from University of New Hampshire, 1910. Assistant in chemistry, 1910–1911, Rensselaer Polytechnic Institute, Troy, N. Y. Fellow, Mellon Institute, 1911–1914. M.S. degree University of Pittsburgh, 1913. Instructor in chemistry, Carnegie Institute of Technology, 1914–1915. Fellow, Mellon Institute 1915–1917. Findlay Clay Pot Co. Fellowship, Mellon Institute, 1916–1917. Sales engineer, Pittsburgh office, Surface Combustion Company of New York, 1917–1921. Pittsburgh Representative, the U. G. I. Contracting Company, Philadelphia, 1921 to date. Honorary member, Alpha Chi Sigma. Member of the AMERICAN CERAMIC SOCIETY, 1917, active member, 1923, Amer. Chem. Soc., Engineers Soc. of W. Pa. Published several papers on "Surface combustion" and "Water gas." Contribution to *Journal*, 1923, "Cold clean artificial gas" and a discussion upon the "General properties of gaseous fuels."

A. E. BLAKE

James C. Boudreau

Studied art in Boston, New York and Paris. Student in education at Columbia University and the University of Pittsburgh. Student in ceramics at the University of Pittsburgh and Alfred University. Served as aviator during the war. Particular interest in ceramic art education as it functions in the elementary and high schools. Became member of the AMERICAN CERAMIC SOCIETY in 1921, active member, 1923. Is Vice-chairman of the Art Division of this SOCIETY and Chairman of the Committee on Education of the same Division. Contribution to *Journal*, 1923, "Clay as a medium through which educational ideals may be effectively presented."



J. C. BOUDREAU

W. F. Brown

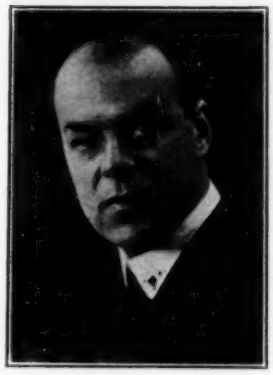
Was graduated Cornell University 1915, specialized in chemistry. Employed at Ball Bros. Glass Co., Muncie, Indiana. Last year of this service as chief chemist, working with R. L. Frink, then chief engineer. Chemical Warfare Service. Bureau of Standards, Optical Glass Section, for short period, leaving for

position as chief chemist, Libbey-Owens Sheet Glass Co., Charleston, W. Va. Served in this capacity four years. Now working in executive offices of that company, at Toledo, Ohio. Became member of the AMERICAN CERAMIC SOCIETY, 1917, active member, 1921. Representative on Committee on Nominations, Glass Division, this SOCIETY, 1923.

W. F. BROWN

Peter P. Budnikoff

Born, 1885, Smolensk, Russia. Was graduated from the Polytechnical Institute at Riga (Chemical Section) 1911 as engineer technologist. Employed in the manufacturing of electric coals at the station Kudniows near Moscow. From 1912–1914 lectured in chemical technology at the School of Industry and Manufacture at Lodz, Poland. In 1914 was despatched to Augland by the minister of Public Instruction for scientific purposes. From 1914–1916 directed own ceramic works at Smolensk which has existed more than 150 years. In 1916 and 1917 was Administrator of the Manufactory of arms at Moscow. In 1917 voted by the council of professors at Ivanowo-Vosnessensk as docent at the Polytechnical Institute formerly at Riga. Read lectures on mineralogic technology at the Chemie faculty. In 1918 was elected professor in same section. Also read lectures on acid and fire-proof materials on technology of building materials at the Architectural faculty. A member of the scientific council of the Experimental Institute for Silicate at Moscow; German Chemical Society. Since 1918, secretary of the Journal *News of the Polytechnical Institute* at Ivanowo-Vossenensk. Contribution to this *Journal*, 1923, senior author with E. A. Shilov, "The chemistry of the terpene medium for ceramic liquid gold."



P. P. BUDNIKOFF

Bruner Moore Burchfiel

Born in 1898 at Anthony, Kans. Received the degree of A.B. from Southwestern College, Winfield, Kans. in 1918. Was Junior Fellow on the Refractories Manufacturers' Association Fellowship at Mellon Institute in 1918 and 1919. From 1919 to 1921 was a graduate student and assistant instructor in chemistry at the University of California. Received the degree of M.S. in 1920. Since 1921 has been refractories chemist for the Los Angeles Pressed Brick Company, carrying on research work on refractories in the laboratory at their Alberhill, California, plant. Became member AMERICAN CERAMIC SOCIETY in 1921, active member, 1923; member of the American Chemical Society and Sigma Xi. Contribution to this *Journal*, 1923, "Refractory clays of the Alberhill, California deposits."

B. M. BURCHFIEL

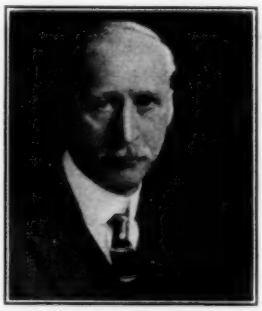
Elmer N. Bunting

Born 1892 at Chicago, Ill. Was educated in the Chicago public schools and the University of Chicago (B.S., 1915, and Ph.D., 1918, in chemistry). During the years 1912–1918 was an assistant in chemistry at the University of Chicago, and in 1918–1919 was employed as a ceramic chemist at the Bausch and Lomb Optical Co., of Rochester, N. Y. Since 1920 has been at the University of Illinois as research associate in the Ceramic Engineering Experiment Station. Became member of this SOCIETY, 1922; active member, 1923. Contribution to *Journal*, 1923, "An electric furnace temperature regulator."

E. N. BUNTING

Frederick Carder

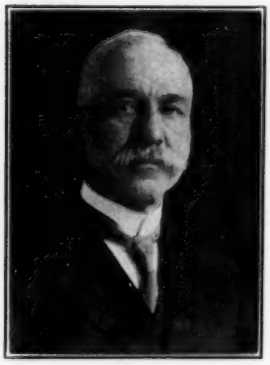
Born in England. Started work in father's pottery getting a practical training in all departments. Obtained position as designer in flint glass factory in England. Obtained a gold medal as well as numerous silver ones for designs in glass. Exhibited works in sculpture at the Royal Academy and was awarded a Traveling Scholarship by the Government. Became Master of a School of Art and Technology. Taught glass-making under the County Council of Staffordshire, one of the first classes in this subject in Europe. Made a report for the County Council of Staffordshire of the glass industries of Germany and Austria. Came to America to make a similar report on glass industry of the United States. In 1903, started the Steuben Glass Works with T. G. Hawkes, manufacturing artistic glass. In 1918 this Company was amalgamated with the Corning Glass Works and was made art director of same. Became member of this SOCIETY 1908 active member, 1919. Contribution to *Journal*, 1923, "Artistic glassware." Also Councilor, Art Division, this SOCIETY.



F. CARDER

Charles W. Crane

Born in New Jersey. Began business career in shipping trade with membership at present in the Maratime Exchange of New York. Financially assisted a mine of clay in 1893, saving operator from failure. 1903, incorporated the business under name of Crossman Company, now President and Treasurer of Company, South Amboy, N. J. Trustee of Manufacturers' Association of New Jersey, Vice-president, New Jersey Manufacturers' Casualty Insurance Company and of New Jersey Manufacturers' Association Fire Insurance Company. Became member of this SOCIETY, 1917, active member, 1920. Vice-president, Eastern Section, this SOCIETY, 1923.



C. W. CRANE

J. L. Crawford

J. L. CRAWFORD

Was graduated ceramic engineering, University of Illinois, 1917. Served in Army one year during war. With Westinghouse Lamps Company eighteen months. During past four years has been Industrial Fellow at Mellon Institute, making special study of glasshouse refractories. Became member of this SOCIETY in 1916, active member, 1921. Contribution to *Journal*, 1923, "High alumina refractories."

W. J. Darby

W. J. DARBY

Born at Florence, Alabama, 1900. Graduated, University of Alabama in 1922, receiving B.S. degree in Chemical Engineering. In August, 1922, was awarded a Research Fellowship at the Missouri School of Mines and Metallurgy, in coöperation with the U. S. Bureau of Mines. Now connected with the Research Division of the New Jersey Zinc Company. Joint author with B. M. O'Harra in *Journal*, 1923, "The disintegration of refractory brick by carbon monoxide."

Frank W. Davis

Born Milford, Delaware, 1889. Graduate Lehigh University. Member A. I. M. M. E., Amer. Iron and Steel Institute and Amer. Electro-Chemical Society. Eight years with the Alan Wood Iron and Steel Co. Four months with 110th Infantry, sixteen months with Ordnance Department, U. S. A. Is now metallurgist, U. S. Bureau of Mines, New York City. Contribution to *Journal*, 1923, "Outline of refractories requirements for the iron and steel industry."

Harry E. Davis

F. W. DAVIS

Was graduated from Ohio State University, Department of Ceramics, 1919. Was employed with the O. W. Ketchum Terra Cotta Company, Crum Lynn, Pa. With the Northwestern Terra Cotta Company. Chicago, since 1920. November, 1923, took position as head of the terra cotta department of the Tropico Potteries Company, Glendale, Calif. Became member of the AMERICAN CERAMIC SOCIETY, 1919, active member, 1923. Secretary and member of Executive Committee of the Chicago Section, this SOCIETY, 1923.

Conrad Dressler

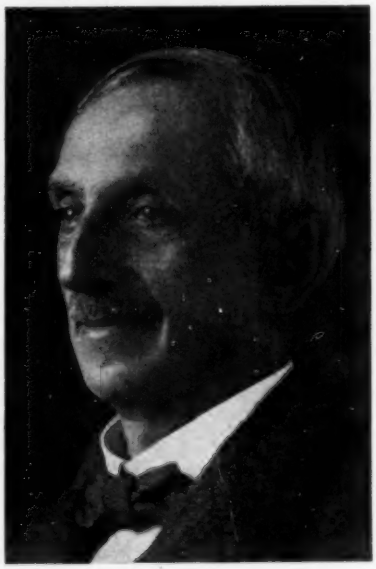
Born Streatham, England. Educated in France and England. Studied at South Kensinger and under Sir Edgar Boehm. Opened studio in Chelsea with small kiln about 1888. In 1893 started the Della Robbia pottery at Birkenhead. Built the Medmenham Pottery, 1896. Made the friezes which surround the Hall of the Law Society, the decoration for the Humphrey Museum,

H. E. DAVIS

Cambridge and the Music Room, Winchester School. Worked on sculpturing 1904–1908. Returned to pottery and developed ideas on tunnel kiln. Built first industrial tunnel kiln, 1911. Dressler Tunnel Ovens Company organized. Built first Dressler tunnel kiln in America in 1915. Settled permanently in America in 1919. Actively engaged in the art of sculpture at studio in Cleveland. Became member of this SOCIETY, 1920, active member, 1921. Contribution to *Journal*, 1923, "The artistic needs of modern faience." Member Committee on Data, Art Division, this SOCIETY.

Warren E. Emley

Received B.S. degree, University of Michigan, 1906, and degree of Ch.E. in 1912. Employed as chemist from 1906–1908, Fletcher Paper Company, Alpena, Michigan. In 1909 connected with the Technologic Branch of the U. S. Geological Survey at Pittsburgh. This work taken over by U. S. Bureau of Standards, 1910. Resigned 1917 to become Assistant to the President of the Riverton Lime Company, Riverton, Va. Returned to Bureau in Washington, 1918. Specialties, lime, gypsum and sand-lime brick. Chairman, Gypsum Committee and Secretary, Brick Committee, A. S. T. M. Honorary member Sand-Lime Brick Association since 1910. Represented U. S. Department of Commerce, Brazilian International Centennial Exposition and the A. S. T. M. at the International Engineering Congress in Rio de Janeiro. Became member of this SOCIETY in 1913, active member, 1915. Senior author of paper with E. B. Berger in *Journal*, 1923, "Panel tests of lime plaster."



CONRAD DRESSLER

G. P. FACKT

G. P. Fackt

Born at Mascoutah, Illinois, 1884. Was graduated from Ohio State University, 1907, with degree of engineer of mines in ceramics. Went to work for the St. Louis Terra Cotta Company as ceramic chemist, remaining there until 1911. Organized the Denver Terra Cotta Company and was vice-president and general manager. This plant was recently purchased

by the Northwestern Terra Cotta Company. Was made president and general manager of the Denver Terra Cotta Company, which retains its identity. Became member of the AMERICAN CERAMIC SOCIETY in 1907, active member, 1919. Councilor for Terra Cotta Division, this SOCIETY, 1923.

R. F. FERGUSON

Robert F. Ferguson

Born at Everett, Pa., 1895. Graduated from the University of Pittsburgh, 1916. Served in the Chemical Warfare Service, Development Division, 1918. Junior Fellow, Refractories Manufacturers' Association Fellowship, Mellon Institute of Industrial Research, University of Pittsburgh, 1919 to date. Secretary, Refractories Division, AMERICAN CERAMIC SOCIETY, 1923. Became a member of this SOCIETY, 1918. Member Committee on Standards. Joint author with R. M. Howe in *Journal*, 1923, "Composition and properties of diaspore bauxite and gibbsite," and with R. M. Howe and S. M. Phelps, "The action of slag upon silica, magnesite, chrome, diaspore and fire clay refractories."

F. C. FLINT

Francis C. Flint

Born in Chicago, Ill., in 1891. Graduated from Pomona College in southern California, 1915. Did graduate work in the University of California. Taught chemistry in college for a while, going into research again during the war. Became member of this SOCIETY, 1919. Has been with the Hazel-Atlas Glass Company since 1920.

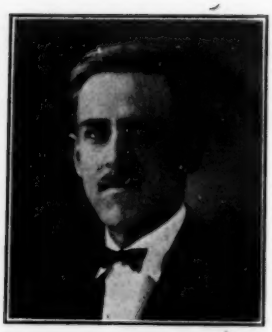
Andrew Foltz

President of the Lambertville Pottery Company. Became member of this SOCIETY, 1920, active member, 1921. President of the Eastern Section of this SOCIETY and Chairman of the Executive Committee of the same Section.

A. FOLTZ

Harry D. Foster

Born at Thornville, Ohio, in 1898. Received bachelor's degree in engineering at Ohio State University in 1920, specializing in ceramics. Employed with Mosaic Tile Company in Zanesville during 1919. Since graduation connected with the U. S. Bureau of Standards in coöperation with the Hollow Building Tile Association, on the fire-resistive and other physical properties of hollow building tile. Became member this SOCIETY, 1919, active member, 1923. Member of the A. S. T. M., Committee C-10 on Hollow Building Tile. Contribution to *Journal*, 1923, "Capping for



H. D. FOSTER

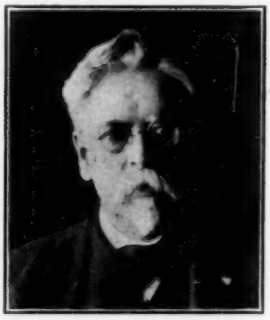
compression specimens," and "Effect of grog addition on the fire resistance of hollow tile."

Frank F. Frederick

Director, The School of Industrial Arts, Trenton, N. J. Contribution to *Journal*, 1923, "School of Industrial Arts," City of Trenton.

Myrtle Merritt French

Was graduated from the New York State School of Clay Working and Ceramics at Alfred University, Alfred, N. Y., in 1913, receiving a B.S. degree. 1913–1914 did graduate work at same school; 1914–1915 taught in high school; 1915–1916 taught pottery in Alfred University; 1916–1920 taught pottery and weaving in Carnegie Institute of Technology at Pittsburgh, Pa. From 1921 to present time taught pottery and weaving in Chicago Art Institute. Summers and 1916 studied design at Columbia University, New York; 1917 studied ceramics at Alfred; 1918 to present time taught ceramics at Alfred. 1923 received Frank Logan medal at Chicago Art Institute for pottery. Contribution to *Journal*, 1923, "The problem of the turquoise alkaline glaze."



F. F. FREDERICK

C. E. Fulton

Was graduated from Rutgers College, 1911, B.S. degree in ceramics. Held ceramic fellowship at the University of Illinois, 1911–1912. Became laboratory assistant in the research department with the Pittsburgh Plate Glass Company in July, 1912. January 1, 1917 to present time, chief engineer with the same Company. Became member of the AMERICAN CERAMIC SOCIETY 1911, active member 1915. Member of Committee on Standards (Products) for the Glass Division, this SOCIETY, 1923. In recent years a contributor to the *Journal*.

MYRTLE M. FRENCH

T. W. Garve

Graduate mechanical engineer. Joined the Richardson-Lovejoy Engineering Company in 1907 after previous experience as machinist and designer, continuing with the Lovejoy Engineering Company until 1916. During the latter years took the ceramic course at Ohio State University. Practical experience as burner on continuous and periodic kilns with the Hebron Fire & Pressed Brick Co., Hebron, N. Dak., Waynesfield Tile Works, Waynesfield, Ohio, and the Barbourville Brick Company, Barbourville, Ky. During 1917 was in charge of the shop and business of the Ceramic Supply & Construction Co., Columbus, O., then designer for the Atlas Portland Cement Company, Northampton, Pa., the Findlay Clay Pot Company, Washington, Pa., and the Chain-Belt Company, Milwaukee,

Wis. During 1919, 1920, 1921 and 1922 was construction engineer for the Franklin Brick & Tile Co., Columbus, Ohio, and then for the Clay Products Company of America, New Hope, Pa. During summer, 1922, in charge of burning and kiln remodeling for the Paxtonville plant of the Watsontown Brick Company, Watsontown, Pa. From fall 1922 until fall 1923 construction engineer for the combined plants of the Franklin Brick & Tile Co., Columbus, Ohio, and the Clay Products Company, Brazil, Ind. At present with the Findlay Clay Pot Company, Washington, Pa. Became member of the AMERICAN CERAMIC SOCIETY in 1910, active member in 1913. Contribution to *Journal*, 1923, "Construction features of importance to clay plants."

T. W. GARVE

G. P. Gavin

Received technical training, Lane Technical School, Chicago, Illinois. Assisted in several potteries in Chicago and the East. From New Jersey took position as superintendent of the Kalamazoo Sanitary Manufacturing Company, Kalamazoo, Mich. Contribution to *Journal*, 1923, with F. M. Hartford, "A recent installation of a Harrop tunnel kiln."

C. F. GEIGER

Charles F. Geiger

Graduate, ceramic engineering, University of Illinois. Research assistant in same department one year. Instructor in ceramics, Rutgers College, two years. Located at Camp Dix, New Jersey and U. S. Bureau of Standards, Pittsburgh for investigative work on airplane spark plugs, light aggregate for concrete ships during the war. Employed with the Carborundum Company, Niagara Falls in 1919 for research and application work on silicon carbide and clay refractories. Transferred to refractories division, same Company, Perth Amboy, N. J. in 1920 as refractories engineer in the production and application of silicon carbide and other superior refractories, high temperature cements, fire clay refractories, etc. Became active member this SOCIETY, 1920. Contribution to *Journal*, 1923, "The history of the development of silicon carbide refractories."

R. F. GELLER

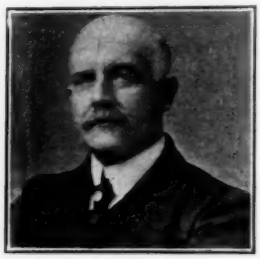
R. F. Geller

Born in Fowler, Michigan, 1895. Received B.S. degree in chemical engineering in 1918, University of Michigan. Since leaving the University has been connected with the Bureau of Standards; is now chief of the Refractories Section of the Ceramic Division. Became member, this SOCIETY, 1919, active member, 1921. Is now chairman of the Committee on Stand-

ards. Active member of the A. S. T. M. and is at present a member of Committee C-8 on Refractories and Committee C-10 on Hollow Building Tile. Contributions to *Journal*, 1923, "Progress report on specifications for refractories." Senior author with A. N. Finn, "Further studies on cast glass pots."

Horace W. Gillett

Born Steuben County, N. Y., 1883. Received degrees of A.B., 1906 and Ph.D., 1910, Cornell. Assistant chemist, Cornell, 1906–1907; chemist, A. D. Little, Inc., 1907–1908; assistant in chemistry, Cornell, 1908–1910; manager, research department, Aluminum Castings Company, 1910–1912. From 1912 to present time chief alloy chemist, U. S. Bureau of Mines, New York City. Member, Chemical Society, Electrochemical Society, Mining Engineers and British Institute of Metals. Contribution to *Journal*, 1923, "Metallurgical requirements of refractories for furnaces melting copper alloys."



A. A. GRANGER

Albert Alexander Granger

Born at Paris in 1866. Began career at the Faculté des Sciences of Paris in the laboratory of chemical researches. Was assistant of analytic chemistry 1889–1891. Became professor of ceramic technology and chemistry at the Ceramic School of the Sèvres Manufactory in 1894 at the time of the creation of this school. Received degree of Doctor of Science, 1898. Lecturer for ceramic glass and cement at the École Municipale de Physique et Chimie Industrielles de la Ville de Paris, 1902–1914. Chief of the testing laboratory of the Manufactory at the Sèvres Laboratory, 1909. First researches bore upon inorganic chemistry; at Sèvres spent entire time with questions concerning ceramic and glass industry. Contribution to *Journal*, 1923, "The ceramic industry of France at the end of the 19th century."

Flemmon Porter Hall

Received B.E. degree in 1918 from Vanderbilt University. Was employed at a Government Powder Plant as chemist during 1918. Was employed at Bureau of Standards in the Ceramic Division during 1919–1920. Received S.M. degree from Massachusetts Institute of Technology in 1921. Up until October 1 this year was employed as associate chemist at Bureau of Standards in Ceramic Division. Is now taking graduate work in the department of physical chemistry, Massachusetts Institute of Technology. Became member of this SOCIETY, 1921, active member, 1923. Contribution to *Journal*, 1923, "Effect of hydrogen ion concentration upon clay suspensions."

F. P. HALL

Carl B. Harrop

Engineer of Mines, Ohio State University, 1902; Assistant chemist, Bronson Portland Cement Co., Bronson, Mich., 1902; assistant chemist, National Portland Cement Co., Durham, Ontario, 1903; chief draftsman with W. D. Richardson, brickworks engi-

neer, Columbus, Ohio, 1904; secretary, The Richardson-Lovejoy Engineering Co., Columbus, Ohio, 1905–1910; estimator, The Kilbourne & Jacobs Mfg. Co., Columbus, Ohio, 1907–1910; secretary, treasurer and manager, the Ceramic Supply & Construction Co., Columbus, Ohio, 1910–1913; vice-president, the Richardson-Lovejoy Engineering Co., 1913–1916; part-time instructor of ceramic engineering, Ohio State University, 1910–1913; assistant professor of ceramic engineering, Ohio State University, 1913–1923; in private consulting engineering practice, specializing on continuous tunnel kilns, since 1918. Became member of the AMERICAN CERAMIC SOCIETY, 1914, active member, 1917. Chairman, Committee on Rules, Heavy Clay Products Division, this SOCIETY, 1923.

C. B. HARROP

Theodore D. Hartshorn

Born in Kensington, Md. Graduated from Dartmouth College in 1921 with B.S. degree in Chemistry. In 1918, employed in Chemical Warfare Service, Washington, D. C. In 1920, employed by Hooker Electrochemical Company, Niagara Falls, N. Y. For the past two years connected with the Enameled Metals Section, U. S. Bureau of Standards, Washington, D. C. Joined AMERICAN CERAMIC SOCIETY in 1922, became active member in 1923. Chairman of Committee on Data of the Enamel Division, this SOCIETY for 1923.

T. D. HARTSHORN

Frank M. Hartford

Born, New Philadelphia, Ohio, 1897. Received engineering education, 1916–1918, Ohio State University. Employed with the Chelsea China Company, New Cumberland, W. Va., and since that time associated with Carl B. Harrop, Engineers and Constructors, Columbus, Ohio. Became member of the AMERICAN CERAMIC SOCIETY, 1920, active member, 1923. Joint contributor to *Journal*, 1923 with G. P. Gavin, "A recent installation of a Harrop tunnel kiln."

F. M. HARTFORD

Fred T. Heath

Born, Tacoma, Wash. Entered University of Washington, Seattle, Wash. in 1915 studying architecture. Commissioned in Coast Artillery Corps and transferred to Air Service as observer during the war. Reentered the University of Washington in the newly established ceramics department. Received B.S. degree in 1922, the first degree in ceramic engineering granted at that University. Associated with Prof. Hewitt Wilson during survey of clays and the ceramic industry of the Northwest. Spent one year conducting research stud-

ies in the hollow building tile design with the Heath Unit Tile Company, Tacoma. Received ceramic research fellowship sustained jointly by the Ceramic Station, U. S. Bureau of Mines, of Columbus and the Engineering Experiment Station, Ohio State University, conducting research pertaining to heavy clay products until June, 1924. Became member this SOCIETY, 1919, active member, 1923. Joint author with Hewitt Wilson and A. L. Bennett, *Journal*, 1923, of paper entitled, "Preliminary report on residual kaolin and feldspar in the Pacific Northwest."

F. T. HEATH

Perry D. Helser

Born at Thornville, Ohio, in 1893. Graduated in Ceramic Engineering from the Ohio State University in 1917. One year, Ceramic Engineer with Mosaic Tile Company of Zanesville, Ohio. One year's service as Lieutenant in the Chemical Warfare Service, U. S. A., manufacturing toxic gas at Edgewood Arsenal, Edgewood, Md. Up to the present time connected with the A. C. Spark Plug Company of Flint, Mich., as ceramic engineer. Joined AMERICAN CERAMIC SOCIETY, 1917. Vice-chairman, Detroit Local Section, this SOCIETY, 1923.

P. D. HELSER

Henry W. Hess

Received early training at Toledo High Schools and Scott Manual Training. Graduated from University of Michigan and took post graduate work there. Was first associated with the Toledo Gas Light and Coke Company and for many years with the Libbey Glass Company. For past three years has been consulting chemical engineer in glass, ceramic and fuel industries, Toledo. Became member of the AMERICAN CERAMIC SOCIETY, 1918, active member, 1921. Contribution to *Bulletin*, 1923, "Observations on the European glass industries."

H. W. HESS

L. C. Hewitt

Received degree of B.S. in ceramics, Iowa State College, Ames, Iowa, in 1917. Conducted experimental work for Iowa State Geological Survey during the summer of 1917, followed by work with the Lacelede-Christy Clay Products Company at St. Louis, Mo. conducting research work in humidity drying. Since February, 1921, has occupied the position of ceramic engineer for the same company, having charge of the research work connected with the development and application of refractories, specifications for drying clays, composition of mixes and processes of manufacturing. Became member of the AMERICAN CERAMIC SOCIETY in 1919, active member in 1923. Contribution

to *Bulletin*, 1923, "Notes on the burning of refractories with special reference to control of labor costs."

L. C. HEWITT

Charles W. Hill

Born in Clarion, Iowa in 1884. Graduated in chemistry, University of Minnesota, 1905. Received M.A. degree, 1907, and Ph.D. degree in 1910 in inorganic and physical chemistry at the University of Wisconsin. Instructor in chemistry at Wisconsin and associate professor of chemistry at the University of Syracuse. Chemist for St. Paul Gas Company, Laclede Gas Company. Assistant director of Research Laboratories, National Carbon Company. Research chemist in charge of inorganic chemistry, Westinghouse Research Laboratory. One of the founders of the Cleveland Research Laboratory and the Cleveland Electro-Metals Company. Since 1920, General Works Manager for the Atlantic Terra Cotta Company. Has published largely in this *Journal* and other technical publications. Has taken patents on various arc carbons, solders and an indicator and control for furnace atmospheres. Main interest for several years in technical control of factory processes. Active member this SOCIETY since 1920. Chairman of Committee on Standards, Terra Cotta Division.

C. W. HILL

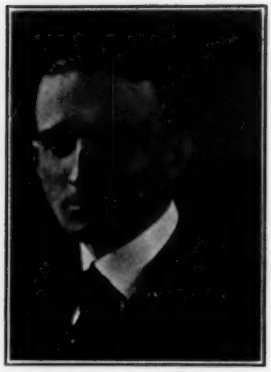
E. C. Hill

Received degree of ceramic engineer from Ohio State University, 1911. Employed in the research department of the Pittsburgh Plate Glass Company from 1911 to 1912. Ceramist with the New York Architectural Terra Cotta Company, Long Island City, N. Y., 1912–1919. Ceramist with the Conkling Armstrong Terra Cotta Company, Philadelphia, Pa. Active member of the AMERICAN CERAMIC SOCIETY since 1912. Chairman of Committee on Data and representative on Committee on Nominations of Terra Cotta Division of SOCIETY, 1923.

E. C. HILL

Roy A. Horning

Born at Hutsonville, Illinois. Was graduated from the University of Illinois, Ceramics Department, 1914. Employed 1914 to 1916 by Armstrong Cork Co., Beaver Falls, Pa., doing research work on heat transmission. Entered service May 1917, commissioned in Engineer Corps, later commissioned first lieutenant in Coast Artillery, went to France with 50th Artillery in 1918. Discharged from the army June, 1919. Returned to the Armstrong Cork Co., Beaver Falls, Pa., and devoted most of the time to efficiency work. Manager of the Lancaster Brick Co., Lancaster, Pa. Became member of the AMERICAN CERAMIC SOCIETY, 1916, active member, 1919. Contribution to *Journal*, 1923, "Experiences with Dutch kilns."



R. A. HORNING

William Otis Hotchkiss

Born Eau Claire, Wis., 1878. Received degrees of B.S., 1903, C.E., 1908, Ph.D., 1916, from the University of Wisconsin. Economic geologist, Wisconsin Geological and Natural History Survey since 1907, director since 1919. State geologist since 1909. Contribution to *Journal*, 1923, "Geology of the Baraboo ganister deposits."

W. O. HOTCHKISS

Herbert Insley

Was graduated from Hamilton College in 1914 and received degree of Ph.D. from the Johns Hopkins University in 1919, specializing in geology. Has been an associate geologist with the U. S. Geological Survey and a petrologist with the U. S. Bureau of Mines. At present he is petrographer for the U. S. Bureau of Standards. Is engaged in research on the constitution of ceramic raw materials and products. Became a member of the AMERICAN CERAMIC SOCIETY, 1922, active member, 1923. Fellow of the Mineralogical Society of America and a member of the Geological Society of Washington. Contribution to *Journal*, 1923, "A study of the origin and cause of stones in glass."

H. INSLEY

R. B. Keplinger

Received A.B. degree, Cornell, 1911. Ceramic work, University of Illinois, 1913 and 1914. With Metropolitan Paving Brick Company from 1911 to present time as time keeper, superintendent, general superintendent and assistant general manager. Became member of the AMERICAN CERAMIC SOCIETY, 1914, active member, 1920. Is Chairman of Heavy Clay Products Division, this SOCIETY, 1923.

R. B. KEPLINGER

R. M. King

Born and reared in Texas. Entered University of Texas in 1912 taking B.A. in chemistry 1916. Chief chemist Alcoa Tennessee Works, Aluminum Company of America for three years. Research Engineer in Electrode Plants, Badin, N. C., and Niagara Falls Works

Aluminum Company of America for two years. Production Superintendent of Carbon Electrode Plant, Alcoa Tennessee Works Aluminum Company of America for one year. Studied ceramics at Ohio State University from Feb., 1922 to June, 1923, taking the degree of Master of Science. Now doing development work for American Lava Corporation, Chattanooga, Tennessee, in coöperation with the U. S. Bureau of Mines Ceramic Station, Columbus, Ohio. Became member of the AMERICAN CERAMIC SOCIETY, 1923. Contribution with A. S. Watts to *Journal*, 1923, "The transfer of heat through refractories and its determination."

R. M. KING

A. A. KLEIN

A. A. Klein

Born, Syracuse, N. Y., 1889. Employed with Semet-Solvay Company, 1906–1907. Attended the University of Michigan 1907–11. Assistant in mineralogy, 1908–1911. With Bureau of Standards, 1916. With Norton Company, Worcester, Mass., 1916 to date. Active member of AMERICAN CERAMIC SOCIETY since 1912. Councilor, New England Section, this SOCIETY, 1923. Joint author with M. C. Booze to *Journal*, 1923, "A rapid means for the determination of the quartz content of feldspar."

H. F. KRIEGE

Herbert Frick Kriege

Born, Omaha, Nebr., 1895. Received B.S. degree Central Wesleyan College, Mo., 1916; A.M. University of Missouri, 1921; post graduate University of Missouri. Taught Iowa High Schools, 1916–1918. Served with Coast Artillery Aug., 1918–Jan., 1919. Instructor, analytical chemistry, University of Mo., 1921–1923. At present chemist with Missouri State Highway Commission. Contribution to *Journal*, 1923, "Effect of time and temperature on the chlorination of flint fire clay."

J. B. KRAK

J. B. Krak

Was graduated Fresenius' Laboratory, '07. Received B.S. degree from West Virginia University, 1912. Chemist, West Virginia Geological Survey, 1908–1920. Consulting chemist, United States Window Glass Company, 1914–1920. Technical editor of *The Glass Industry* since 1920. Became member of the AMERICAN CERAMIC SOCIETY, 1921, made active mem-

J. D. LALOR

ber, 1923. Contribution to *Journal*, 1923, "The glass industry."

James D. Lalor

Born in Philadelphia in 1870. Received engineering education under private tutor. Occupied for twenty years with construction work around Philadelphia. Chief engineer and built the Philippine Exposition at Louisiana Purchase Exposition, 1903–1904. In 1909, developed the Lalor Automatic Shut-off and Drain Valves for the protection o fuel oil systems, with factory established in Baltimore, 1913. In 1920, placed Lalor Fuel Oil System on the market. Contribution to *Journal*, 1923, "How to install and operate a fuel oil system."

C. H LAWSON

Carl H. Lawson

Born, Fall River, Mass., 1893. Entered the employ of the Norton Company, Worcester, Mass., in 1908. Served apprenticeship five years in the plant. In 1913 entered the research laboratory of the same company under Ross C. Purdy (then research director). Eight years on factory research work. Superintendent of the Waltham Grinding Wheel Company since 1921. Became member of the AMERICAN CERAMIC SOCIETY, 1917; active member, 1923. Secretary-Treasurer of the Northeastern Section this SOCIETY, 1923.

T. LENCHNER

Theodore Lenchner

Born, New York City, in 1888. Graduated Pennsylvania State College with degree of B.S. in 1912. From 1912 to 1914 with the American Vanadium Company. From 1914–1920, superintendent with the O. Hommel Company, Pittsburgh, Pa., consulting chemist, 1920–1922. Accepted position with the Vitro Manufacturing Company in summer of 1922. Became member of the AMERICAN CERAMIC SOCIETY, 1923. Contribution to *Journal*, 1923, "Glass decorators' palette and its decoration."

P. C. LEONARD

Phil C. Leonard

Born, Joliet, Ill., 1892. Was graduated, 1916, from Lombard College, B.S.degree. Served three years as by-product foreman Dover By-Product Coke Co.,

Dover, Ohio; two years silica work at Joliet for American Coke & Chemical Co., and about three and one-half years with American Refractories Co. Sales work, in charge Chicago office last year before consolidating with present General Refractories Company. At present a salesman with this Company. Became member of the AMERICAN CERAMIC SOCIETY, 1923. Representative on Committee on Nominations, Refractories Division, this SOCIETY, 1923.

J. T. LITTLETON, JR.

Jesse Talbot Littleton, Jr.

Born, Belle Haven, Va., 1887. Received A.B. degree Southern University (Alabama), 1906; fellow, Tulane, 1906–1908, A.M. degree, 1908; Ph.D. degree, University of Wisconsin, 1911. Instructor, University of Michigan, 1911–1913. Since 1913, chief, physical laboratory, Corning Glass Works, Corning, N. Y. Research work centered upon optical constants of metals, alloys and steels, and the mechanical and physical properties of glass. Member, A. A. A. S. and the Physical Society. Contribution to *Journal*, 1923, "The relative magnitude of radiation and convection heating in a muffle kiln."

A. MALINOVSKY

A. Malinovsky

Born at Vienna, Austria, in 1875. Worked in father's plant where stove tile, floor tile and enameled ware was manufactured. Finished the State Real and Gymnasium School at Lauban, Germany. Received instructions in ceramics, and has been employed in different countries in Europe in manufacturing refractory porcelain and enameled sanitary and kitchen utensils. In America has been employed by Randolph and Co., Chicago, Ill. as chemist, developing processes and soils, with the Malinite Co., Belleville Ill., Blackmer and Post, St. Louis, Mo., U. S. Smelting Furnace Co., Belleville, Ill. At present is employed at the Washington Iron Works, Los Angeles, Calif. Has designed and remodeled enameling plants and has done consulting work. Became member of the AMERICAN CERAMIC SOCIETY in 1915; active member, 1923. Is a member of the American Institute of Chemical Engineers, Advance of Science, Illinois State Academy, American and British Ceramic Society, Chairman of the new California section of this SOCIETY. Contribution to *Journal*, 1923, "Method of cooling enamel by compressed air."

M. E. MANSON

Mahlon E. Manson

Born, Terre Haute, Ind., 1895. Graduated from Rose Polytechnic Institute, 1916, as chemical engineer.

Worked as a chemist after graduation for Armour & Co. and Butte & Superior Mining Co. before entering the army. Served overseas with 90th Division. After discharge, worked in Sears-Roebuck laboratory until coming to the Rundle Manufacturing Co. in 1920 as chief chemist. Active member of this SOCIETY since 1921. Contribution to *Journal*, 1923, "The use of bentonite for suspending enamels."

J. D. MARTIN

John D. Martin

Born 1880, Cleveland, Ohio. Was graduated from Ohio State University, 1901, degree Mechanical Engineer. With Pennsylvania Railroad 1901–1904 as special apprentice, motive power department during part of which time acted as member of locomotive testing department at St. Louis Exposition. In June, 1905, took charge of plant of Straitsville Impervious Brick Company, of Thomas Moulding Brick Company, New Straitsville, Ohio. In 1915 also took charge of plant of Buckeye Fire Brick and Clay Company under same ownership, located at Scioto Furnace, Ohio. Is voter in the SOCIETY for the Straitsville Impervious Brick Company, corporation member. Contribution to *Journal*, 1923, "Automatic kiln stokers."

George E. Middleton

Born January, 1890, in Washington, D. C. Received degree of Ceramic Engineer from Ohio State University, 1912. Chemist, Northern Clay Co., Auburn, Washington, 1912–1913. Assistant examiner U. S. Patent Office, 1913–1919. Attended George Washington University, 1913–1916, receiving degree of B.A. Attended George Washington University Law School, 1916–1919. Assistant in patent department of Norton Company, Worcester, Mass., 1919–1920. Associated with the patent law firm of Pennie, Davis, Marvin & Edmonds, 165 Broadway, New York City, from 1920 to the present time. Became member of the AMERICAN CERAMIC SOCIETY, 1914; active member, 1923. Contribution to *Bulletin*, 1923, "Inventions and patents —some phases of the patent law."

Robert J. Montgomery

Was graduated from Ohio State University in 1911 with the degree of Ceramic Engineer. Until 1915 studied and manufactured glass house refractories in the research laboratory of the Pittsburgh Plate Glass Company. In charge of the refractories and high temperature division of the H. Koppers Company's laboratory at the Mellon Institute, Pittsburgh, 1916–1917, working on the standardization of coke oven refractories. Took the position of ceramic engineer with the Bausch and Lomb Optical Co., Rochester, N. Y., in 1917. Assisted in the development and manufacture of optical glass during that period of the war when it was so badly needed by the Army and Navy. Now in charge of the technical work connected with the manufacture of optical glass, ophthalmic or spectacle glass, both clear and colored, and the manufacture of glass pots of special composition required for this type of work. Became member of the AMERICAN CERAMIC

R. J. MONTGOMERY

SOCIETY, 1912; made active member of this SOCIETY in 1916. Contribution to *Journal*, 1923, "Opthalmic glass, a new American product."

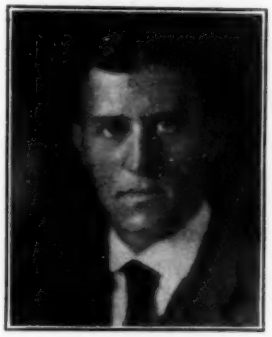
Donald A. Moulton

D. A. MOULTON

Born, Ironton, Ohio. Was graduated from Ohio State University in 1908. Became superintendent Condit Forks Brick Company, Condit Falls, Canada until 1913. With the McLain Fire Brick Company, Wellsville, Ohio, in 1920. Since that time professor in the department of ceramic engineering, Iowa State College, Ames, Iowa. Became member of the AMERICAN CERAMIC SOCIETY in 1908, now active member. Joint author with Paul E. Cox of paper in *Journal*, 1923, "A new raw material for ceramic uses."

Alexander Ector Orr Munsell

Born in Brookline, Mass., 1895. Was graduated from Harvard, 1918. Served in France nine months. Went into the Munsell Color Company which is concerned in the manufacture of Munsell color standards and supplies. Now director of the Munsell Research Laboratory, established in 1923 in memory of Albert H. Munsell, his father, the originator of the Munsell Color System. The laboratory has been located in Baltimore so that it may gain the valuable coöperation of Johns Hopkins University in Baltimore and the Bureau of Standards in Washington. Contribution to *Journal*, 1923, "Simple method of measuring color."



A. E. O. MUNSELL

Louis Navias

Born in Grodno, Russia, 1897. Received education, through high school, in Johannesburg, South Africa, matriculating from King Edward VII School in 1913. In the summer of 1914, attended the Columbia University. Transferred to the College of the City of New York, graduating in 1918 with the B.S. degree in chemistry. For two years, 1918–1920, was employed in the glass plant of the Bausch and Lomb Optical Company, Rochester, New York, doing analytical and research work in connection with optical glass. In 1920, came to the University of Illinois for graduate work. Was a Fellow for the two years, 1920–1922. He received the M.S. degree in ceramic chemistry in 1921. Made active member of Sigma Xi in 1921. Became member of this SOCIETY, 1919, active member, 1923. Contribution to *Journal*, 1923, "Measurement of heat absorbed and evolved by clays during firing and burning."

L. NAVIAS

F. P. NICKERSON

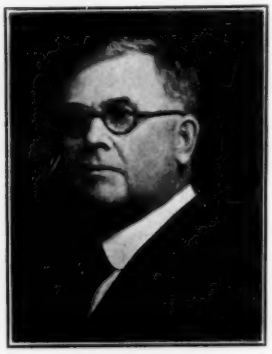
F. P. Nickerson

Born and reared in Nebraska. After completing early engineering training, entered employ to Deckman-Duty Paving Brick Company, Cleveland, Ohio. Later became field engineer with the Bonnot Company until outbreak of war. Took position of designing engineer for the General Refractories Company. Since 1920 has been employed with the W. S. Tyler Company. Became member of the AMERICAN CERAMIC SOCIETY, 1922. Contribution to *Journal*, 1923, "The value of screen analysis in ceramics."

B. M. O'HARRA

B. M. O'Harra

Born 1894. Graduated from the South Dakota School of Mines 1915; chemist, American Smelting and Refining Company, Omaha, Nebr., 1915–1917; Research Metallurgist, American Smelting and Refining Company, Omaha, Nebr., 1917–1919; superintendent of electrolytic lead refinery and bismuth plant, American Smelting & Refining Company, Omaha, Nebr., 1919–1921; associate metallurgist, U. S. Bureau of Mines, Mississippi Valley Experiment Station, Rolla, Mo., 1921. Member A. I. M. M. E., and Am. Electrochem. Society. Contributions to *Journal*, 1923, "Metallurgical requirements for refractories in the electrothermic metallurgy of zinc," and senior author with W. J. Darby, "The disintegration of refractory brick by carbon monoxide."



F. T. OWENS

Francis T. Owens

Connected with Fiske and Company, Inc., for past thirteen years. Twelve years in production end of the business. Now vice-president. Joined the AMERICAN CERAMIC SOCIETY, 1917; became active member, 1919. Contribution to *Bulletin*, 1923, "Importance of figuring taxes into costs."

A. R. PAYNE

A. R. Payne

Born in Illinois in 1891. Was graduated High School Redlands, Calif., 1909. Graduated Pomona College, Claremont, Calif., 1913, B.S. degree. Attended University of California 1913–1916 as graduate student in physics. Received M.S. degree in 1914. Taught

San Diego Night High School and Coronado High School, 1916–1917. Assistant physicist, U. S. Bureau of Standards, 1917–1919, Washington and Pittsburgh Laboratories. During war in charge of inspection of optical glass for Bureau. Chief Physicist, Hazel-Atlas Glass Company, Clarksburg, W. Va., 1919 to date. Joined the AMERICAN CERAMIC SOCIETY in 1920; became active member, 1921. Chairman, Glass Division, AMERICAN CERAMIC SOCIETY, 1923.

A. B. PECK

Albert B. Peck

Born at Syracuse, N. Y., 1892. A.B. Syracuse University, 1914., A.M. University of Michigan, 1915. Assistant in mineralogy, University of Michigan, 1914–1916. Instructor in mineralogy, University of Michigan, 1916–1917. Assistant and associate physicist, U. S. Bureau of Standards, 1917–1920, in charge of petrographic microscopic investigations of ceramic materials, assistant professor of mineralogy, University of Michigan 1920 to present time. Became member of the AMERICAN CERAMIC SOCIETY in 1920, active member, 1921. Member Sigma Xi, Alpha Chi Sigma (chemical), Fellow, Mineralogical Society, President, Detroit Section, this SOCIETY, 1923.

G. ST. J. PERROTT

G. St. John Perrott

B.A., 1914, and M.A., 1915, North Dakota, physics and chemistry. Two years graduate work in physical chemistry at Princeton University. 1917–1919, Chemical Warfare Service on war gas work (1st Lieut. 1918–1919). Feb.–Oct., 1919, Bureau of Mines surveying carbon black industry. 1919–1920, at Salt Lake City with Smoke Abatement Investigation. 1920–1921, Trent Process Corporation on coöperative work with Bureau of Mines, Pittsburgh. 1921–1923, coke investigation at Bureau of Mines, Tuscaloosa, Ala., 1923. Investigation of Liquid Oxygen Explosives, Bureau of Mines, Pittsburgh. Senior author with S. P. Kinney, *Journal*, 1923, "The meaning and microscopic measurement of average particle size."

A. P. POTTS

Amos P. Potts

Was graduated as ceramic engineer from Ohio State University, 1912. Assistant professor, ceramic engineering, Iowa State College, Ames, Ia., 1912–1913, and associate professor, 1913–1914. Ceramic engineer, Mason City Brick and Tile Company, Mason City, Ia., 1914–1920. Local manager, Seguin Brick and Tile Company, McQueeny, Texas, 1920–1922. Ceramic engineer, The Clay Products Company, Brazil, Indiana, 1922 to date; loaned to the Franklin Brick and

Tile Company as acting superintendent, September, 1922 to June, 1923. Became member this SOCIETY, 1911; active member, 1914. Secretary and Chairman of the Committee on Papers and Programs, Heavy Clay Products Division, this SOCIETY, 1923.

F. R. PYNE

Francis R. Pyne

Graduated from Lehigh University in 1906 with degree of metallurgical engineer. With Boston and Montana Copper Co., Great Falls, Mont., 1906–1909. With United States Metals Refining Co., Carteret, N. J., 1909–1923. With Nichols Copper Co., Laurel Hill, N. Y., at the present time as assistant general superintendent. Made various contributions to the technical press and engineering society transactions on metallurgical subjects. Author of the articles on roasting and copper smelting in Liddell's "Handbook of Chemical Engineering." Contribution to *Journal*, 1923, "Metallurgical requirements of refractories in copper smelting and refining."

Joseph P. Rodgers

Has been actively engaged in the preparation of feldspar for the ceramic industry for the past thirty years. Experience obtained with the Brandywine Summit Kaolin & Feldspar Co., who were favorably known in the business for a great many years. For the past four years has been interested in the Product Sales Co., and he is also treasurer of the Clinchfield Sand & Feldspar Co. Chairman, of Committee on Standards (Tests) in White Wares Division, this SOCIETY, 1923. Became member of the AMERICAN CERAMIC SOCIETY, 1922.

J. P. RODGERS

Charles I. Rose

Born in St. Louis, Mo. in 1901. Received an M.S. degree in Ceramics, and a B.S. in Chemical Engineering at the University of Illinois. Since graduation has been employed in research work on abrasives. Became a member of the AMERICAN CERAMIC SOCIETY, 1922, also American Chemical Society. Contribution to *Journal*, 1923, "Proposed method for studying the attack of molten slags and glasses upon refractory materials."

A. D. SABORSKY

Arthur D. Saborsky

Born in Vienna. Spent the earlier business years in Europe. After graduating from the Engineering College in Berlin, worked for Austrian, German, Italian and English firms, finally settling permanently in the United States. Adopted the engineering of special purpose machinery as particular line, and has

been consulting engineer this branch ever since, located in Cleveland, Ohio. During the depression period of 1921 went to Europe on an "engineering sightseeing" trip. Examined practically all of Europe for new features of engineering, which have developed during the past years of turmoil and readjustment, but due to unbalanced conditions had not reached America. In this connection, found and investigated the progress which manufacture and use of glass wool has taken in Europe. Contribution to *Journal*, 1923, "Glass wool heat insulation in Europe."

H. A. Schwartz

Native of Oldham Co., Kentucky. Was graduated Rose Polytechnic, 1901, M.S. degree, 1903., M.E. degree, 1905. National Malleable Castings Co. at Indianapolis in 1902. Was placed in charge of the entire corporation's malleable metallurgical practice. Since 1920 Manager of Research for the same Company at its Cleveland headquarters. Author of "American Malleable Cast Iron," Member of Amer. Soc. Mech. Engineers, Amer. Chem. Soc., A. I. M. M. E., Society of Automotive Engineers, British Iron and Steel Institute, Amer. Foundrymen's Assoc. Senior author with A. F. Gorton, *Journal*, 1923. "The requirements of fire brick suited to malleable practice."

Carl Schwier

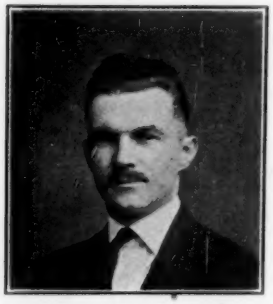
Born in Mansfield Ohio, 1898. Attended college at Western Reserve University and Case School of Applied Science at Cleveland and graduated with a degree of A.B. from the former institution and a B.S. in chemical engineering from the latter in June, 1921. In 1918, spent some months at Camp Zachary Taylor and was commissioned Second Lieutenant in Field Artillery. Entered the employ of the Mansfield Vitreous Enameling Co. in 1921 and for four months worked in all departments of the plant doing all operations in the wet enameling of sheet steel and cast iron. Since that time has remained with the same firm in the capacities of chemical engineer and superintendent and is the present plant superintendent. Joined the AMERICAN CERAMIC SOCIETY, 1921. Became active member, 1923. Contribution to *Journal*, 1923, "An electric furnace for vitreous enameling."

C. SCHWIER

MARY G. SHEERER

Mary G. Sheerer

Born in Kentucky. Studied drawing and painting, Cincinnati Art Academy. Received scholarship to Frank Duveneck's class in oil painting from life and other teachers. Teacher and assistant director, Newcomb Pottery, New Orleans. Became member of the AMERICAN CERAMIC SOCIETY, 1922. Member Arts and Craft Association. Contribution to *Bulletin*, 1923, "Exhibition of industrially made table ware." Also Councilor Art Division of this SOCIETY.



M. SHEPPARD

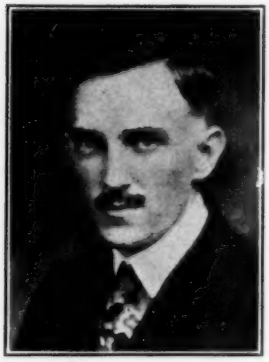
Mark Sheppard

Received B.S. in Ceramic Engineering, Alfred University, 1919. Industrial Fellow, Mellon Institute of Industrial Research, 1919–1921. Ceramic Engineer, E. J. Lavino and Company, 1921–1923. Joined the AMERICAN CERAMIC SOCIETY in 1920; became active member, 1923. Contribution to *Journal*, 1923, "Zirconia Refractories."

H. H. Sortwell

H. H. SORTWELL

Born at Lawrenceburg, Ind. Was graduated from University of Illinois in ceramic engineering in 1918. Entered Navy, commissioned for engineering duty, and served overseas. Spent one year with the U. S. Encaustic Tile Works, Indianapolis. Three years at the Bureau of Standards, working on whiteware materials and problems. At present time, ceramic engineer for the Star Porcelain Company, the Frenchtown Porcelain Company, and the Washington Porcelain Company, with headquarters at the Star Porcelain Company, Trenton, N. J. Joined the AMERICAN CERAMIC SOCIETY, 1917; active member, 1921. Contributions to *Journal*, 1923, "The effect of variation in firing on the physical properties of vitreous china bodies" and "Impact tests on tableware."



C. D. SPENCER

Charles D. Spencer

Born in Jacksonville, Florida. Attended the University of Chicago. At present associate physicist, Glass Technology Department, National Lamp Works of General Electric Co., Cleveland, Ohio. Senior author with A. E. Badger, *Journal*, 1913, "A skiagraphic study of fabricated glass articles."

Ira E. Sproat

I. E. SPROAT

Was graduated Ohio State University, ceramic engineering, 1911. Ceramic engineer, three years, Dayton Grinding Wheel Company, Dayton, Ohio. Assistant Ceramic Engineer, U. S. Bureau of Mines, Washington, D. C. one year. Two years with Georgia Kaolin Company, Macon, Ga. Consulting ceramic engineer, Sebring China Company and Limoges China Company, Sebring, Ohio. Past year, manager, pottery department, R. T. Vanderbilt Company, New

York City. Joined the AMERICAN CERAMIC SOCIETY, 1912; became active member, 1920. Member American Chemical Society and A. S. T. M. Chairman of Committee on Membership, White Wares Division, this SOCIETY, 1923. Contribution to *Journal*, 1923, "Effect of heat treatment and composition of semi-porcelain bodies on crazing."

D. F. STEVENS

Douglas F. Stevens

Born in Minneapolis, Minnesota, 1893. Attended Northwestern University and Cornell University, Ithaca, N. Y. Received degree of M. E. from Cornell, 1907. Entered employment of the Acme Brick Company after graduation and has been vice-president and general manager of the Company since 1922. Became member of the AMERICAN CERAMIC SOCIETY, 1913, active member, 1921. Also member of the Illinois Clay Manufacturers Association, National Brick Manufacturers Assoc and American Face Brick Assoc. Is Chairman of the Committee on Membership, Heavy Clay Products Division, this SOCIETY, 1923.

F. L. STEINHOFF

F. L. Steinhoff

Born in Chicago, 1894. Graduated from department of ceramics, University of Illinois, 1917. Since that time connected with Industrial Publications, Inc., as field man, associate editor, and at present managing editor of *Brick and Clay Record*. Is editor of the new journal started in June, called *Ceramic Industry*. Also collaborator with the Clay Products Cyclopedia. Joined the AMERICAN CERAMIC SOCIETY, 1917; became active member, 1919. With W. D. Gates in 1917, organized Chicago Section of this SOCIETY. Is chairman of Committee on Papers and Programs, this year. Contributions to *Journal*, "The log (twenty-five years) of progress in the brick and tile industry" and "Brick and clay record, its history."

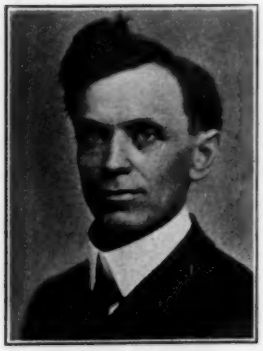
W. J. Stephani

Born in Bellville, Ill., 1881. Graduated from St. Louis Manual Training School, 1900, Ohio State University, 1900–1903. Excelsior Terra Cotta Co., 1904–1906. Planned and built O. W. Ketcham Terra Cotta Works, 1906. Associated at this time there. Joined the AMERICAN CERAMIC SOCIETY, 1906; became active member, 1912. Councilor, Terra Cotta Division, this SOCIETY, 1923.

W. J. STEPHANI

C. O. Swanson

Received A.B. degree Carleton College, Minn., 1899, M.Agr. 1905, College of Agriculture, University



C. O. SWANSON

of Minnesota; Ph.D., 1922, Cornell University. Teacher of science and Agricultural Chemistry. Head of Department of Milling Industry, July, 1923 to present time. State Agricultural College, Manhattan, Kans., Jan. 1918–July 1919, technologist in cereal dust explosion work with the U. S. Dept. of Agriculture, Bureau of Chemistry. Contribution to *Journal*, 1923, "The origin, distribution and meaning of laterite."

Mark A. Taylor

M. A. TAYLOR

Received degree of B.S. in ceramic engineering at Iowa State College in 1921. One year (1919–20), served as despatcher and chief despatcher, Christy Plant of the Laclede-Christy Company, of St. Louis, Mo. This work was under the direction of Dwight T. Farnham, industrial engineer. Since July, 1921, has been employed by the Vincent Clay Products Company of Fort Dodge, Iowa, as ceramic engineer. At present has charge of the drying, setting, and kiln burning departments. Became member of this SOCIETY, 1922. Contribution to *Journal*, 1923, "Fuel oil as adapted to the chambered continuous kiln."

G. E. THOMAS

George E. Thomas

Educated in mechanical lines, spent several years studying the production and manufacture of glass house refractories under father, a clay working and mining engineer from the Starbridge Clay fields, England. Has been connected for fifteen years with the Highlands Fire Clay Company, St. Louis, Mo., is general manager and superintendent. Member of the AMERICAN CERAMIC SOCIETY, 1911, active member in 1923. Chairman, Membership Committee, St. Louis local section, this SOCIETY.

Frederick S. Thompson

F. S. THOMPSON

Degree of Bachelor of Arts from Defiance College and degrees of B.S. and chemical engineer from Case School of Applied Science. Teacher and principal of high school at Le Grand and Colton, Cal., 1913–1917. Assistant manager, Rhode Island Division of the National Lamp Works of the General Electric Co., 1917–1923. Since February of 1923

with glass technology department of same company, Nela Park, Cleveland. Contribution to *Journal*, 1923, "Substituting fuel oil for producer gas in a continuous glass tank."

Charles B. Thwing

C. B. THWING

Was graduated from Northwestern University and the University of Bonn. Was instructor in Physics at Northwestern and Wisconsin and Professor of Physics at Knox College and Syracuse University. Author of two textbooks on physical measurement and of numerous contributions to scientific periodicals. Since 1906 has been engaged in the manufacture of pyrometers and other scientific instruments at Philadelphia. Has invented numerous improvements in pyrometry and has specialized in pyrometers for the ceramic industry. Became member in the SOCIETY, 1917. Contribution to *Journal*, 1923, "Cold end compensation of a pyrometer system."

Karl Turk

KARL TURK

Received initial training in enameling under Theodore Zwerman, Sr., of the Baltimore Enamel and Novelty Company. Worked with the "wet" process for cast iron, particularly stove work. Vice-president, Porcelain Enamel and Manufacturing Company of Baltimore, vice-president, Wolverine Porcelain Enameling Company, Detroit, Mich., and the Scranton Enameling Company, Scranton, Pa., all operating under the "Penn." System. Joined AMERICAN CERAMIC SOCIETY, 1917; became active member, 1921. Chairman, Membership Committee, Enamel Division, this SOCIETY, 1923.

Robert Twells, Jr.

Born in Independence, Ohio, 1895. Worked at sanding molds and in various capacities in plants making sewer pipe, hollow blocks, paving and common brick. In 1914, worked for the Key-James Brick Company, Chattanooga, Tennessee, as foreman of shipping department. Withdrew from the University of Illinois to enter Army service in May, 1917. Was graduated with B.S. degree in ceramic engineering in 1920. Member Tau Beta Pi and Sigma Tau, honorary engineering fraternities, and Keramos, honorary ceramic fraternity. Worked with the General Electric Company, Schenectady, N. Y. Since 1921 employed with the Champion Porcelain Company, now assistant superintendent. Member in SOCIETY since 1920. Chairman, Membership Committee, Detroit Section, this SOCIETY. Contributions to *Journal*, 1923, "Further studies of porcelain glazes, maturing at high temperature" and "Tests on some sagger clays and bodies."

R. TWELLS, JR.

C. A. UNDERWOOD

C. A. Underwood

Was graduated in 1915 from the Worcester Polytechnic Institute. Afterwards served one and one-half years in field of organic chemistry. Associated with Harbison-Walker Refractories Company three years as chemist and representative in the magnesite field in state of Washington. Served in Chemical Warfare Service during war. Later was chief chemist for American Refractories Company three and one-half years. At present connected with sales department of Queen's Run Refractories Co. Became member of the AMERICAN CERAMIC SOCIETY, 1922, active member, 1923. Contribution to *Journal*, 1923, "The analysis of refractories," and to *Bulletin*, 1923, "The analysis of high alumina products."

James G. Vail

Was graduated from Westtown School, Philadelphia, 1904. Became chemist with the Philadelphia Quartz Company; now secretary and chemical director of same company. Took additional work at the University of Pennsylvania, Harvard University and the Institute of Technology in Darmstadt, Germany. Under American Relief Administration directed feeding of under-nourished children in Hamburg, and shipment of supplies into Germany. Member of AMERICAN CERAMIC SOCIETY, 1922; American Institute of Chemical Engineers, Society of Chemical Industry, and the American Chemical Society. Contribution to *Journal*, 1923, "Silicate of soda in the ceramic industry."

J. G. VAIL

A. S. Walden

Has been employed with the National Carbon Company, Inc., Cleveland, Ohio, in the production and engineering departments for twenty-eight years. Became member of the AMERICAN CERAMIC SOCIETY, 1917, active member, 1919. Chairman of the Executive Committee of the Northern Ohio Section, this SOCIETY, 1923.

A. S. WALDEN

Robert A. Weaver

Graduate of Kenyon College. Instructor of English and director of athletics, DoVoe College one year. Assistant sales manager and advertising manager of Eclipse Stove Company for two years, Advertising manager for the Favorite Stove and Range Company for two years. Sales manager for the Porcelain Enamel and Manufacturing Company for two and one-half years. President of the Scranton Enameling Company for one year. Vice-president, Philadelphia

Porcelain Company for two years, and president of the Ferro Enamel Supply Company four years. Joined AMERICAN CERAMIC SOCIETY, 1922. Chairman, Membership Committee, Northern Ohio Section, this SOCIETY, 1923.

R. A. WEAVER

Norman E. Webster

Attended Union College, Schenectady, N. Y. and National Law School, Washington, D. C., receiving degrees of Master of Arts and Master of Laws. Founder and president of the Association of American Government Accountants, and member of the Michigan Association of Certified Public Accountants, of the New York State Society of Certified Public Accountants, of the National Association of Cost Accountants. Now vice-president of the American Institute of Accountants. Five years as chief accountant for the United States Reclamation Service, and since 1909 as a member of Niles & Niles, Certified Public Accountants at 111 Broadway, New York City, and 53 State Street, Boston. Has given especial attention to the cost problems of the ceramic industries. Contribution to *Bulletin*, 1923, "Pricing and costing graded products."

N. E. WEBSTER

Francis C. Welch

Born in Salem, Mass. in 1898. Received B.S. degree, Catholic University, 1920. From 1920–1923 worked as chemist on gypsum at U. S. Bureau of Standards. Now research associate for Gypsum Industries at the Bureau. Contribution to *Journal*, 1923, "Effect of accelerators and retarders on calcined gypsum."

W. F. Wenning

Received education in chemical engineering at Carnegie Institute of Technology and the University of Pittsburgh. Served as Ensign in the United States Navy. At present, head of research and service department, Vitro Manufacturing Company of Pittsburgh. Working on research problems which deal with the manufacture and application of chemicals for ceramic products, specializing in cast and sheet iron enamels. Joined the AMERICAN CERAMIC SOCIETY, 1921; became active member, 1923. Contribution to *Bulletin*, 1923, "Zirconia in sheet iron enamels."

W. F. WENNING

S. Wiester

Came to this country in 1912 for three months to the Enterprise Stamping & Enameling Co., Bellaire, Ohio, to abolish some faults of fabrication on kitchen utensils. Completed this work successfully and was retained by that company until 1914. Equipped the

Baltimore Stamping & Enameling Co. for white kitchenware, which department was closed down in 1916 on account of the war. Took charge of building and equipping the enameling plant of the Malleable Iron Range Company, Beaver Dam, Wis., and supervised it until 1921. In 1922, built and equipped the enameling plant for the Lackawanna Foundry Company, Dickson City, Pa. At present is with the Ironton Stove & Mfg. Co., Ironton, Ohio, to build and equip their new enameling plant, consisting of three Wiester patented fuel oil fired furnaces and to supervise the plant after it is finished. Became member of the AMERICAN CERAMIC SOCIETY, 1920; active member, 1923. Contribution to *Journal*, 1923, "Air-cooled *versus* water-quenched enamels."

S. WIESTER

Eugene P. Wightman

Born Baltimore, Md., 1888; B.S. Richmond College, Va., 1908; Ph.D. Johns Hopkins University, Baltimore, Md., 1911; Carnegie research assistant in physical chemistry, Johns Hopkins University, 1911–1914; instructor in chemistry, Washington University, St. Louis, 1914–1915; Fellow, Mellon Institute, Pittsburgh, 1915–1916; acting professor of chemistry, Richmond College, Va., 1916–1917; research chemist, Parke, Davis and Company, Detroit, 1917–1918 and 1919–1920; 1st Lieut., U. S. A. Chemical Warfare Service, 1918–1919; research chemist, Eastman Kodak Co., Rochester, N. Y., since March, 1920. Member American Chemical Society, American Association Advertising Science, Royal Photographers Society of Great Britain, Pictorial Photographers of America. Contribution to *Bulletin*, 1923, discussion on "The meaning and measurement of average particle size."

A. G. WIKOFF

Alan G. Wikoff

Received B. S. degree, College of the City of New York, 1916, majoring in chemistry. M.A. degree, Columbia University, 1917. During 1916 was associated with the Kathol Mfg. Company, then making a substitute for the photographic developer, Metol, using a process involving the electrolytic reduction of organic compounds. During 1917–1918 was chemist for the Waring Mfg. Company, Yonkers, N. Y. From April to December, 1918, with Chemical Warfare Service, assigned to mustard gas plants at Hastings-on-Hudson, N. Y. and Midland, Mich. Joined staff of *Chemical & Metallurgical Engineering*, January, 1919, as Assistant Editor. Became member of this SOCIETY, 1922. Contributions to *Journal*, 1923, "Chemical and metallurgical engineering" and "Refractory requirements for oil refining." A member of the Committee on Membership for the Refractories Division.

C. E. WILLIAMS

Clyde E. Williams

G. A. WIILLIAMS

Superintendent and metallurgist, U. S. Bureau of Mines, Northwest Experiment Station, Seattle, Wash. Engaged in research work on electrometallurgy, metallurgy of iron and steel, and refractories. Contribution to *Journal*, 1923, "Requirements of refractories for electric furnaces."

George A. Williams

W. S. WILLIAMS

Born at Peffard, N. Y., 1887. Graduate of Geneseo Normal School, Geneseo, N. Y. Graduate of Alfred University, class of 1913. Professor of ceramics, Rutgers College, New Brunswick for 4 years. Altantic Terra Cotta Co., as chemist, six years. At present with Wunderlich Ltd., Sydney, Australia. Joined AMERICAN CERAMIC SOCIETY, 1921; became active member, 1923. Joint author with W. L. Howat, *Bulletin*, 1923, "Testing barium carbonate for use in terra cotta bodies."

W. S. Williams

S. S. WYER

Received B.S., University of Illinois, 1909. Practical factory experience in architectural terra cotta, floor and wall tile, optical glass, flint and window glass refractories. Became member of SOCIETY, 1919, active member, 1921. Contribution to *Journal*, 1923, "Effect of various sizes of gray particles on clay pots."

Samuel S. Wyer

Born Wayne County, Ohio, 1879. Received M.E. degree, Ohio State University, 1903. Consulting engineer since 1905. Chief of natural gas conservation, Fuel Administration, consulting engineer, U. S. Bureau of Standard, 1918, and U. S. Bureau of Mines, 1920. Member of A. A. A. S., Mechanical Engineers, Mining Engineers, American Gas Institute. Contribution to *Bulletin*, 1923, "Memorandum on power situation in United States in million horse power."

D. C. WYSOR

D. C. Wysor

Born near Dublin, Pulaski County, Virginia. Graduated from Virginia Polytechnic Institute, 1910 with B.S. degree in applied geology. Post graduate studies in geology and engineering, 1910–1911. Civil engineering on location of electrical transmission lines in Virginia and West Virginia. Assistant on Missouri Geological Survey. Mining geologist, General Chemical

Company, 1914 to date. Industrial research in this position carried on in United States, Canada and Cuba. Special work also in Western United States for Nichols Copper Company. Became member of the AMERICAN CERAMIC SOCIETY, 1922. Contribution to *Journal*, 1923, "Diaspore clay of Arkansas and Missouri."

A. S. ZOPFI

A. S. Zopfi

Born 1874 in Sullivan County, N. Y. Educated in country schools, taught school two years. Entered employ of the Findlay Clay Pot Company, Findlay, Ohio, in 1894. In 1909 with W. K. Brownlee organized the Buckeye Clay Pot Company, Toledo, Ohio, holding office of secretary and treasurer, and still continues in such capacity. No technical degree or special training. Became member of the AMERICAN CERAMIC SOCIETY, 1909, active member, 1921. Chairman, Northern Ohio Section, this SOCIETY.

NOTES AND NEWS

CERAMIC DEPARTMENT OF GEORGIA SCHOOL OF TECHNOLOGY

On December 3, 1923, ground was broken for the new ceramics building at Georgia School of Technology. When completed it will house the only Department of Ceramics in the South. For the present, one wing 50 feet wide and 83 feet long, will be built and equipped with a complete clay testing laboratory. Plans, however, contemplate the addition in the future of a two-floor structure, 40 feet wide and 100 feet long. Dark red rough texture brick and terra cotta will be used for construction.

Due to the enthusiastic coöperation of the clay and other industries of Georgia, $40,000 have been subscribed for equipment and maintenance. Among the contributors are the following:

Fulton County		B. Mifflin Hood Brick Co.	
Cash	$10,000	Building material	$1,500
Bickerstaff Brick Co.		B. Mifflin Hood	
50,000 brick	500	Equipment	.....
J. C. Steel and Sons		Stevens Pottery	
Equipment	2,000	Firebrick	.....
W. G. Massee-Bibb Brick Co.		Central of Georgia Railway	
10 carloads of brick	1,500	Laboratory equipment	1,500
S. G. Warner		Atlanta Terra Cotta Co.	
Contractor's services	.....	Cash	1,000
William Wilson		Atlanta Chamber of Commerce	
Painter's services	.....	Cash	250
Paint dealer of Atlanta		Milledgeville Brick Co.	
Paint	200	30 carloads of brick	4,500
J. B. McGrary & Co.		Edgar Brothers Co.	
Cash	500	Cash	500
M. C. Kiser		Roper, Strauss, Ferst Co., Inc.	
Cash	200	40,000 sq. ft. floor tile	.....

The general assembly of Georgia, largely through the efforts of Senator Carswell, has voted the department an appropriation of $10,000 per year for maintenance beginning January.

Arthur V. Henry of Ohio State University is to be the head of the new Ceramic Department. He received the degree of Ceramic Engineer in 1914, Master of Science in 1921 and will receive the degree of Doctor of Philosophy before taking up his duties on February 1st. He has had six years' experience in the clay industry and served three years during the war as captain of artillery.

A. V. Henry

The establishment of the department is the outcome of a study of the ceramic colleges throughout the country, by Dr. Brittain, president of Georgia Tech. The investigation covered a period of more than one year and included information gathered at numerous meetings of the leaders in the clay industry.

Georgia offers a large field for ceramic research. It has vast beds of kaolins, bauxites, refractory clays, feldspars, fullers' earth and many other minerals, which for the greatest part are still undeveloped. The new ceramic department should be a big asset to the clay industries of the South.

"FUELS AND FURNACES"

Early this year, a new publication entitled *Fuels and Furnaces* in pocket size and published by F. C. Andresen & Associates, Inc., 709 House Building, Pittsburgh, Pa., made its appearance. The caliber of articles included and the Abstract Section, which is a really unusual feature in a magazine of this kind, are of sufficient merit to warrant its careful perusal by all those who are interested in industrial fuels or furnaces in the iron, steel, automotive, glass, ceramic or other industrial processes in which the subjects of fuels and furnaces is of major importance.

The success of this little publication is undoubtedly in large measure due to: the past experience of F. C. Andresen, president of the company; the wide engineering knowledge of W. Trinks, of the Carnegie Institute of Technology; E. H. McClelland, Abstract Editor and head of the Technology Department of the Carnegie Library at Pittsburgh, and of Elmer C. Cook, formerly managing editor of *Forging & Heat Treating* and the *Blast Furnace & Steel Plant*.

Some indication of the scope of this little publication may be gleaned from the titles of articles selected from the first few issues:

"Fuels and Their Handicaps as Related to Drying Ovens."
"Smoke Regulation in Metallurgical Furnaces."
"A New Radiation Pyrometer for the Measurement of High Temperatures."
"Fuel Consumption of Different Types of Furnaces."
"Coke Oven Gas Plant for the Manufacture of Sheet Glass."
"Electric Melting of Non-ferrous Alloys."
"Enameling Furnace Improved."
"Lead Pot Furnace Design."
"High Frequency Induction Furnaces."
"Furnace for Melting Glass."

"Products Yielded by Carbonization of Coal at Low Temperatures."
"Heat Penetration."
"Will Cheap Oxygen Revolutionize Furnace Problems?"
"Capacities of Electric Melting Furnaces."
"A Day at the Ford Plant."
"New Apparatus Successfully Controls Temperatures."
"Operating Gas Tanks."
"The Determination of Melting Points."
"CO_2 and CO Meters Described."
"Heat Balance of a Glass Tank."
"Rules for Designing Resistors."
"Japanning Department."

Fuels and Furnaces is distributed free of charge and those interested need only write the address given above giving their company name and connection to be placed on the regular mailing list.

R. C. PURDY SPEAKS IN TORONTO

Ross C. Purdy, General Secretary of the AMERICAN CERAMIC SOCIETY, delivered an address before the members of the Society of Chemical Industry in Toronto on the evening of Friday, December 14. Mr. Purdy's subject was "The Vitrification of Clays and Allied Problems in the Ceramic Industry."

INTERNATIONAL EXHIBITION OF MODERN DECORATIVE AND INDUSTRIAL ARTS

BY H. H. MORSE

An international exhibition of modern decorative and industrial arts will be held in Paris in the spring of 1925. The United States has been invited to participate by erecting at an expense of approximately $80,000 a temporary building covering about 5600 square feet of ground.

American industry is going to take an active interest and the Department of Commerce should like to know what business firms or individuals would make exhibits and to what extent they would be willing to appropriate funds for that purpose.

It is proposed that the exhibition itself will have the broadest scope and will take in all that can be produced by the artist, manufacturer and mechanic, bringing together all the decorative arts in every form. Five main groups will be represented, which are subdivided as follows:

Group I. Architecture

Class 1. Architecture.—Class 2. Stone-working (artistic and industrial).—Class 3. Wood-working (artistic and industrial).—Class 4. Metal-working (artistic and industrial).—Class 5. Ceramic-ware (artistic and industrial).—Class 6.—Glass-ware (artistic and industrial).

Group II. Furniture

Class 7. Complete suites.—Class 8. Wood and leather furniture.—Class 9. Fancy articles and articles in morocco leather.—Class 10. Artistic and household

metal goods.—Class 11. Ceramic ware.—Class 12. Cut and blown glass.—Class 13. Textile industry.—Class 14. Paper industry.—Class 15. Book industry.—Class 16. Games and toys, sporting goods and apparatus.—Class 17. Scientific instruments.—Class 18. Musical instruments.—Class 19. Means of conveyance.

Group III. Wearing Apparel

Class 20. Clothing.—Class 21. Millinery, gloves and minor articles.—Class 22. Flowers.—Class 23. Jewelry.

Group IV. Theatrical, Street and Garden Architecture and Decoration

Class 24. Scenery and stage properties.—Class 25. Objects for the adornment of streets and boulevards.—Class 26. Landscape gardening.

Group V. Educational

Class 27. Materials for school.—Class 28. Stone.—Class 29. Wood.—Class 30. Metal.—Class 31. China.—Class 32. Glass.—Class 33. Textiles.—Class 34. Paper.—Class 35. Materials of animal or vegetable origin not elsewhere classified.—Class 36. Photography and Cinematography.

NOTES FROM THE BUREAU OF STANDARDS

Tests of Caustic Magnesia Made from Magnesite from Several Sources

The results of a part of the Bureau of Standard's work on oxychloride cement are contained in Technologic Paper No. 239, which may be obtained from the Superintendent of Documents at 10c a copy.

Comparatively few users of this material are really familiar with it. Even among architects and builders, oxychloride cement products are often known only in connection with trade names. The rapidly increasing demand for these materials shows that they possess certain desirable peculiarities, and has made it necessary to replace haphazard or "rule of thumb" methods in the manufacture and use of this cement with more scientific methods based on the study of numerous tests.

Caustic magnesia, the chief constituent of oxychloride cement, was made in the experimental cement plant of the Bureau of Standards by calcining magnesite ore. The temperature and other conditions were varied in order to study the effects on the properties of the product. An ore imported from Greece, one shipped from the State of Washington, and two from different mines in California were used, as these were representative of the chief sources of supply for this country. Cement mixtures, typical of those used by the trade, were then made, and tested both in the laboratory and on panels of flooring and stucco exposed to actual service conditions.

The results of this work form an important contribution to the information necessary for the production of the most satisfactory oxychloride cement products.

Improved Apparatus for Testing Bricks

An improved apparatus for the transverse testing of brick has been designed by H. L. Whittemore of the Bureau of Standards. During the past month 500 brick were tested to determine whether this apparatus was superior to that specified by the American Society for Testing Materials. 250 brick were tested in each apparatus. The

bricks were of 3 different kinds, 200 being clay brick, 200 cement, and 100 sand-lime brick. The average results were practically the same for both types of testing fixtures but with the Whittemore apparatus it was possible to test 100 brick in 3 hours, while $5^1/_4$ hours were required to test the same number with the A. S. T. M. fixtures. With the latter apparatus, 5 pieces are displaced when a brick is broken, and these must be accurately replaced in position for the next test. There are no displaced parts when a brick is broken in the new holder. Since both devices give equal results for the modulus of rupture of a brick, and since the A. S. T. M. fixture requires more time, the new apparatus is evidently an advance in the field of testing equipment.

Development Test for Hardness of Glazes and Investigation to Increase the Hardness of These Glazes

The Ceramic Division of the Bureau of Standards is developing a hardness test for porcelain glazes which consists essentially in wearing away the glaze by means of a standard sand which is allowed to run through an orifice of known dimensions and to strike upon the inclined surface of the specimen after falling a predetermined distance. Satisfactory results are being obtained in comparatively short intervals of time and with small amounts of sand, both being well within practical limitations. A circular letter has been sent to a considerable number of potters asking that samples be submitted for testing.

Meeting of Advisory Board on Dictionary of Specifications

A meeting was held on October 24th of the Board organized to act in an advisory capacity to the Department of Commerce in compiling material for and publishing a handbook of specifications for commodities purchased by federal, state and municipal governments and public institutions. As was mentioned in last month's *Bulletin*, there are more than 20,000 commodities which can properly be classed as articles purchased out of taxes for which there should be specifications, whereas there are now in existence less than 5000 specifications for such commodities.

At the meeting of the Advisory Board, at which there were present representatives from all but one of the organizations represented on the Board, unanimous approval was voted for the proposed plan for issuing shortly in convenient form a thoroughly classified list of all known existing commodity specifications.

The Board voted unanimously for the creation by the Secretary of Commerce, as Chairman of the Board, of three committees from its membership to render reports for the approval of the Board on the subjects of (1) classification of commodity specifications; (2) form and size of the publication; and (3) scope of the proposed handbook or encyclopedia of specifications.

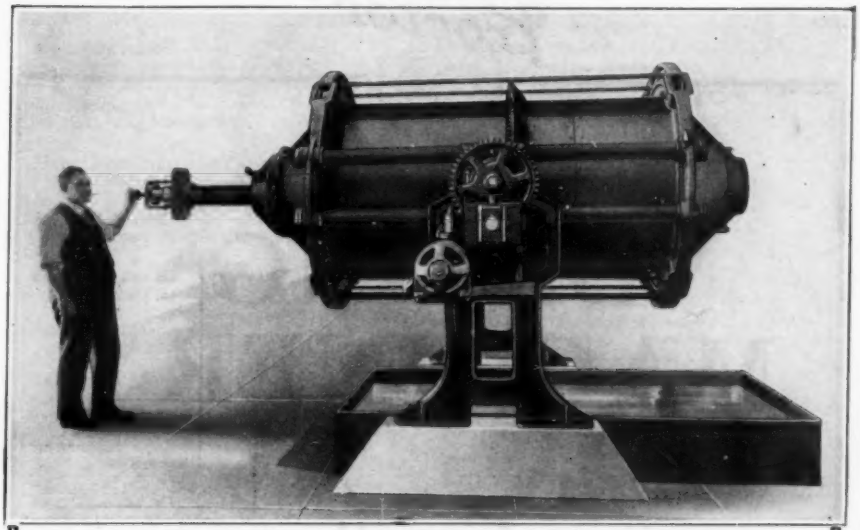
It was the unanimous opinion of the Board that future meetings should be subject to the call of the chair.

CALENDAR OF CONVENTIONS[1]

Organization	Date	Place
AMERICAN CERAMIC SOCIETY (Annual Meeting)	Feb. 4–9, 1924	Atlantic City
American Concrete Institute	Feb. 25–28, 1924	Chicago

[1] Further information may be secured through the Chamber of Commerce of U. S., Washington, and World's Convention Dates, New York, N. Y.

American Institute of Electrical Engineers	Feb. 4–7, 1924	Philadelphia
American Malleable Castings Assn.	Jan., 1924	Cleveland, Ohio(?)
American Road Builder's Assn.	Jan. 14–18, 1924	Chicago
American Zinc Institute	May, 1924	St. Louis, Mo.
Assn. of Scientific Apparatus Makers of U. S. A.	April 18, 1924	Washington, D. C.
Common Brick Mfrs. Assn. of America	Feb. 11, 1924	Los Angeles, Calif.
Gas Products Assn.	Jan., 1924	Chicago
Hollow Bldg. Tile Assn.	Jan., 1924	Chicago(?)
Institute of Metals, Div. of American Institute of Mining and Metallurgical Engineers	Feb., 1924	New York City
Natl. Assn. of Stove Mfrs.	May 7–8, 1924	New York, Hotel Astor
Natl. Bottle Mfrs. Assn.	April 27, 1924	Atlantic City
Natl. Brick Mfrs. Assn.	Jan. 28–Feb. 2, 1924	Cincinnati, Ohio
Natl. Builders Supply Assn., Inc.	Feb., 1924	Chicago(?)
Natl. Electric Light Assn.	May or June, 1924	
Penna. Gas Assn.	April, 1924	Atlantic City
Society of Promotion Engineering Education	July, 1924	Boulder, Colo.
Stoker Mfrs. Assn.	April or May, 1924	(?)
Western Society of Engineers	June 4, 1924	Chicago



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A-B Stove Company, Battle Creek, Mich.
Hall China Company, East Liverpool, Ohio.
Beaver Falls Art Tile Co., Beaver Falls, Pa.
Pacific Sanitary Mfg. Co., Richmond, Cal.
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Vanderbilt Co., R. T.

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United Clay Mines Corp.
Vanderbilt Co., R. T.

Clay (Enamel)
Edgar Brothers Co.
Metal & Thermit Corp.
United Clay Mines Corp.
Vanderbilt Co., R. T.
Vitro Mfg. Co.

Clay (Fire)
Edgar Brothers Co.
Paper Makers Importing Co., (Inc.)
United Clay Mines Corp.

Clay (Potters)
United Clay Mines Corp.
Vanderbilt Co., R. T.

Clay (Sagger)
Edgar Brothers Co.
Paper Makers Importing Co., (Inc.)
United Clay Mines Corp.
Vanderbilt Co., R. T.

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Mueller Machine Co., Inc.

Clay Miners
Edgar Brothers Co.
United Clay Mines Corp.
Vanderbilt Co., R. T.

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Vanderbilt Co., R. T.

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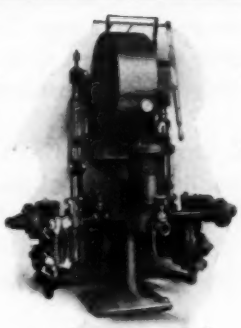

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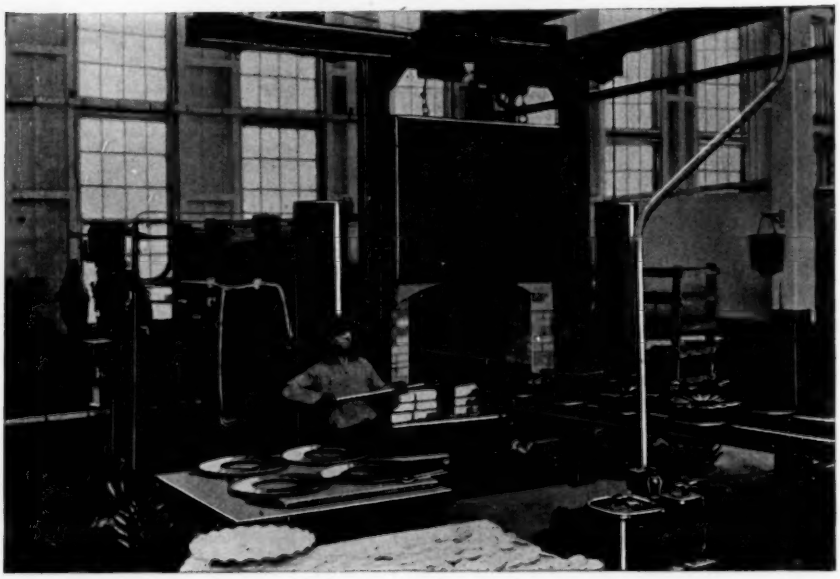

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	PAGE
American Rolling Mill	Inside Back Cover
Bowman Coal Company	16
Brown Instrument Co.	18
Californians, Inc.	12
Ceramic Engineering Co.	23
Chambers Brothers Co.	22
Chicago Vitreous Enamel Product Co., The	1
Drakenfeld and Co., B. F., Inc.	10
Edgar Brothers Co	22
Engelhard, Charles, Inc.	22
Ferro Enamel Supply Co.	27
Gay Co., Rubert M.	23
General Electric Co.	14
Genesee Feldspar Co.	24
Golding-Keene Co.	16
Hadfield-Penfield Steel Co.	17
Hardinge Co., Inc.	8
Harshaw, Fuller and Goodwin Co.	2
Journal of the Society of Glass Technology	20
Lindsay Light Co.	23
Madeira Hill & Company	19
Maine Feldspar Co.	18
McDanel Refractory Porcelain Co.	16
Montgomery Porcelain Products Co.	23
Mueller Machine Co., (Inc.)	13
O'Brien and Fowler	16
Paper Makers Importing Co., (Inc.)	3
Parker-Russell Mining & Mfg. Co.	16
Pennsylvania Pulverizing Co.	19
Pennsylvania Salt Mfg. Co.	28
Philadelphia Drying Machinery Co.	26
Porcelain Enamel & Mfg. Co.	Outside Back Cover
Proctor and Schwartz, Inc.	6
Professional Directory	25
Roessler and Hasslacher Chemical Co.	Inside Front Cover
Seaboard Fuel Corporation	21
United Alloy Steel Co.	26
United Clay Mines Corp.	17
U. S. Smelting Furnace Co.	5
Vanderbilt Co., R. T.	4
Vitro Manufacturing Co.	24
Wilson-Maeulen Co., Inc.	17

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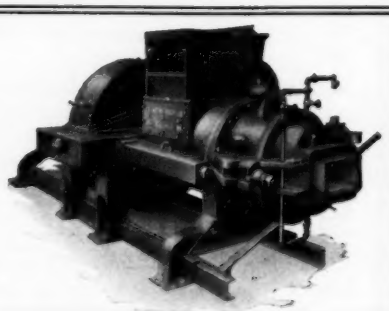

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